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EDMUND RUFFIN, EDITOR AND PROPRIETOR.

ELEMENTS OF AGRICULTURAL CHEMISTRY:

BY SIR HUMPHRY DAVY, BART. LL. D., F. R. S. &c.

PREFACE

TO THE FIRST AMERICAN FROM THE FIFTH AND LAST ENGLISH EDITION.

The text of the last English edition of Davy's Elements of Agricultural Chemistry, is precisely the same with that of 1827, which received the latest alterations and improvements made by its illustrious author. But besides that entire text, this, which will be an exact reprint of the last London edition, has the notes then appended by the pen of the author's brother, and co-laborer in chemical investigation, Dr. John Davy.

No American edition of this valuable work has been published from any later than the first English; and even of those early and imperfect editions, few if any copies can now be found for sale. The work, in booksellers' phrase, has long been "out of print;" and there are very few works that so well deserve to be reprinted, or are more essential to the library of every intelligent agriculturist.

It has therefore been thought that it would be an acceptable and important service to the readers of the Farmers' Register, to furnish them with the last edition of this valuable work, in so cheap a form as the pages of this journal will afford.—ED. FAR. REG.

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ADVERTISEMENT TO THE FIFTH EDITION.

In this edition, the text of the last, to which the advertisement of the author prefixed refers, has been scrupulously preserved unaltered. The only liberty I have taken has been in adding a few foot notes, at the request of the publishers, chiefly relating to facts ascertained since 1826.

JOHN DAVY.

Fort Pitt, Chatham, Nov. 5, 1835.

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ADVERTISEMENT TO THE FOURTH EDITION.

During ten years, from 1802 to 1812, I had the honor, every session, of delivering courses of lectures before the Board of Agriculture. I endeavored, at all times, to follow in them the progress of discovery; they therefore varied every year; and since they were first published in 1813, some considerable improvements have been made in chemical science, which have rendered many alterations and additions necessary.

I am indebted for much useful information to many gentlemen who have endeavored to improve agriculture, and to apply scientific principles to this most important of the arts; of which acknowledgments will be found in the body of the work. I hope there are no omissions on this head; but should they exist, I trust they will be attributed to defect of recollection, and not to any want of candor or of gratitude.

Where I have derived any specific statements from books, I have always quoted them; but I have not always made references to such doctrines as are become current, the authors of which are well known; and which may be almost considered as the property of all enlightened minds.

In revising this work for the fourth edition, I have been forcibly struck with its imperfections, and I regret that I have been able to do so little to render it more worthy of the approbation of those readers for whom it was designed. My object has been principally to dwell upon practical principles, and practical applications of science; and it is in the farm, and not in the laboratory, that these can be put to the test of experiment; and my duties and pursuits have rendered it impossible for me to do more than point out the path of inquiry—to indicate the road to improvement. The manner in which the work has been received, both in this country and the continent, induces me to hope that its object, however humble, has been to a certain extent attained, and that it has not been without its utility.

I have retained an appendix containing an account of the experiments on grasses instituted by the Duke of Bedford at Woburn, because many of these experiments are alluded to in the body of the work. I am happy, however, to be able to refer my readers to a much fuller and more detailed account of this subject of investigation, in a treatise published by Mr. George Sinclair, entitled *Hort. Gram. Woburnensis*, and which, from the nature of the details, and the singular modesty and clearness with which they are given, is well worthy the perusal of all persons interested in agricultural pursuits.

H. DAVY.

Park Street, January 1, 1827.

LECTURE I.

INTRODUCTION. GENERAL VIEWS OF THE OBJECTS OF THE COURSE, AND OF THE ORDER IN WHICH THEY ARE TO BE DISCUSSED.

It is with great pleasure that I receive the permission to address so distinguished and enlightened an audience on the subject of agricultural chemistry.

That any thing which I am able to bring forward, should be thought worthy the attention of the Board of Agriculture, I consider as an honor; and I shall endeavour to prove my gratitude, by employing every exertion to illustrate this department of knowledge, and to point out its uses.

In attempting these objects, the peculiar state of the inquiry presents many difficulties to a lecturer. Agricultural chemistry has not yet received a regular and systematic form. It has been pursued by competent experimenters for a short time only: the doctrines have not as yet been collected into any elementary treatise; and on an occasion when I am obliged to trust so much to my own arrangements, and to my own limited information, I cannot but feel diffident as to the interest that may be excited, and doubtful of the success of the undertaking. I know, however, that your candor will induce you not to expect any thing like a finished work upon a science as yet in its infancy; and I am sure you will receive with indulgence the first attempt made in this country to illustrate it, by a series of experimental demonstrations.

Agricultural chemistry has for its objects all those changes in the arrangements of matter connected with the growth and nourishment of plants; the comparative values of their produce as food; the constitution of soils; the manner in which lands are enriched by manure, or rendered fertile by the different processes of cultivation. Inquiries of such a nature cannot but be interesting and important, both to the theoretical agriculturist, and to the practical farmer. To the first they are necessary in supplying most of the fundamental principles on which the theory of the art depends. To the second they are useful in affording simple and easy experiments for directing his labors, and for enabling him to pursue a certain and systematic plan of improvement.

It is scarcely possible to enter upon any investigation in agriculture without finding it connected, more or less, with doctrines or elucidations derived from chemistry.

If land be unproductive, and a system of ameliorating it is to be attempted, the sure method of obtaining the object is by determining the cause of its sterility, which must necessarily depend upon some defect in the constituton of the soil, which may be easily discovered by chemical analysis.

Some lands of good apparent texture are yet steril in a high degree; and common observaton and common practice afford no means of ascertaining the cause, or of removing the effect. The application of chemical tests in such cases is obvious; for the soil must contain some noxious principle, which may be easily discovered, and probably easily destroyed.

Are any of the salts of iron present? they may be decomposed by lime. Is there an excess of siliceous sand? the system of improvement must depend on the application of clay and calcareous matter. Is there a defect of calcareous matter? the remedy is obvious. Is an excess of vegetable matter indicated? it may be removed by liming, paring, and burning. Is there a deficiency of vegetable matter? it is to be supplied by manure.

A question concerning the different kinds of limestone to be employed in cultivation often occurs. To determine this fully in the common way of experience, would demand a considerable time, perhaps some years, and trials which might be injurious to crops; but by simple chemical tests the nature of a limestone is discovered in a few minutes; and the fitness of its application, whether as a manure for different soils, or as a cement, determined.

Peat earth of a certain consistence and composition is an excellent manure; but there are some varieties of peats which contain so large a quantity of ferruginous matter as to be absolutely poisonous to plants. Nothing can be more simple than the chemical operation for determining the nature, and the probable uses of a subtance of this kind.

There has been no question on which more difference of opinion has existed, than that of the state in which manure ought to be ploughed into the land; whether recent, or when it has gone through the process of fermentation; and this question is still a subject of discussion. But whoever will refer to the simplest principles of chemistry, cannot entertain a doubt on the subject. As soon as dung begins to decompose, it throws off its volatile parts, which are the most valuable and most efficient. Dung which has fermented, so as to become a mere soft cohesive mass, has generally lost from one third to one half of its most useful constituent elements; and, that it may exert its full action upon the plant, and lose none of its nutritive powers, it should evidently be applied much sooner, and long before decomposition has arrived at its ultimate results.

It would be easy to adduce a multitude of other instances of the same kind; but sufficient, I trust, has been said to prove, that the connection of chemistry with agriculture, is not founded on mere vague speculation, but that it offers principles which ought to be understood and followed, and which, in their progression and application, can hardly fail to be highly beneficial to the community.

A view of the objects in this course of lectures, and of the manner in which they are to be treated, will not, I hope, be considered as an improper introduction. It will inform you what you are to expect; it will afford a general idea of the connection of the different parts of the subject, and of their relative importance; it will enable me to give some historical details of the progress of this branch of knowledge, and to reason from what has been ascertained, concerning what remains to be investigated and discovered.

The phenomena of vegetation must be considered as an important branch of the science of organized nature; but though exalted above inorganic matter, vegetables are yet in a great measure dependent for their existence upon its laws. They receive their nourishment from the external elements; they assimilate it by means of peculiar

organs; and it is by examining their physical and chemical constitution, and the substances and powers which act upon them, and the modifications which they undergo, that the scientific principles of agricultural chemistry are obtained.

According to these ideas, it is evident that the study ought to be commenced by some general inquiries into the composition and nature of material bodies, and the laws of their changes. The surface of the earth, the atmosphere, and the water deposited from it, must either together or separately afford all the principles concerned in vegetation; and it is only by examining the chemical nature of these principles, that we are capable of discovering what is the food of plants, and the manner in which this food is supplied and prepared for their nourishment. The principles of the constitution of bodies, consequently, will form the first subject for our consideration.

By methods of analysis dependent upon chemical and electrical instruments dicovered in late times, it has been ascertained that all the varieties of material substances may be resolved into a comparatively small number of bodies, which, as they are not capable of being decompounded, are considered in the present state of chemical knowledge, as elements. The bodies incapable of decomposition at present known are fifty-two.* Of these, forty are metals; eight are inflammable bodies; and five are substances which unite with metals and inflammable bodies, and form with them acids, alkalies, earths, or other analogous compounds. The chemical elements acted upon by attractive powers combine in different aggregates. In their simpler combinations, they produce various crystalline substances, distinguished by the regularity of their forms. In more complicated arrangements, they constitute the varieties of vegetable and animal substances, bear the higher character of organization, and are rendered subservient to the purposes of life. And by the influence of heat, light, and electrical powers, there is a constant series of changes; matter assumes new forms, the destruction of one order of beings tends to the conservation of another; solution and consolidation, decay and renovation, are connected; and whilst the parts of the system continue in a state of fluctuation and change, the order and harmony of the whole remain unalterable.

After a general view has been taken of the nature of the elements, and of the principles of chemical changes, the next object will be the structure and constitution of plants. In all plants there exists a system of tubes or vessels, which in one extremity terminate in roots, and at the other in leaves. It is by the capillary action of the roots that fluid matter is taken up from the soil. The sap, in passing upwards, becomes denser, and more fitted to deposite solid matter: it is modified by exposure to heat, light, and air in the leaves; descends through the bark, in its progress produces new organized matter; and is thus, in its vernal and autumnal flow, the cause of the formation of new parts, and of the more perfect evolution of parts already formed.

* The number is now fifty-four. Since the above was written, thorium has been discovered by Berzelius, and vanadium by Sefström; both of them metals, as their termination indicates.—J. D.

In this part of the inquiry, I shall endeavor to connect together into a general view, the observations of the most enlightened philosophers who have studied the physiology of vegetation. Those of Grew, Malphighi, Sennebier, Darwin, De Candolle, Mirbel, and, above all, of Mr. Knight. He is the latest inquirer into these interesting subjects, and his labors have tended most to illustrate this part of the economy of nature.

The chemical composition of plants has, within the last ten years, been elucidated by the experiments of a number of chemical philosopers, both in this and in other countries; and it forms a beautiful part of general chemistry. It is too extensive to be treated of minutely; but it will be necessary to dwell upon such parts of it, as afford practical inferences.

If the organs of plants be submitted to chemical analysis, it is found that their almost infinite diversity of form depends upon different arrangements and combinations of a very few of the elements; seldom more than seven or eight belong to them, and three constitute the greatest part of their organized matter; and according to the manner in which these elements are disposed, arise the different properties of the products of vegetation, whether employed as food, or for other purposes and wants of life.

The value and uses of every species of agricultural produce, are most correctly estimated and applied, when practical knowledge is assisted by principles derived from chemistry. The compounds in vegetables really nutritive as the food of animals, are very few; farina or the pure matter of starch, gluten,sugar, vegetable jelly, oil, and extract.* Of these the most nutritive is gluten; which approaches nearest in its nature to animal matter, and which is the substance that gives to wheat its superiority over other grain. The next in order as to nourishing power is oil, then sugar, then farina; and last of all, gelatinous and extractive matters. Simple tests of the relative nourishing powers of the different species of food, are the relative quantities of these substances that they afford by analysis; and though taste and appearance must influence the consumption of all articles in years of plenty, yet they are less attended to in times of scarcity, and on such occasions this kind of knowledge may be of the greatest importance. Sugar and farina, or starch, are very similar in composition, and are capable of being converted into each other, by simple chemical processes. In the discussion of their relations, I shall detail to you the results of some recent experiments, which will be found possessed of applications both to the economy of vegetation, and to some important processes of manufacture.

All the varieties of substances found in plants, are produced from the sap; and the sap of plants is derived from water, or from the fluids of the soil, and

* Doubt may be entertained of the number being so limited. As the saw-dust of wood is capable of being converted into a kind of bread, by a peculiar process, it is not improbable that, by the digestive powers of animals, nourishment may be derived from substances analogous to saw-dust, as chaff, &c. In the Ionian islands, where cattle are miserably kept during the winter months, they are fed chiefly on straw, and the horses of the farmer on straw and the cuttings of the vine.—J. D.

it is altered by, or combined with, principles derived from the atmosphere. The influence of the soil, of water, and of air, will therefore be the next subject of consideration. Soils in all cases consist of a mixture of different finely divided earthy matters; with animal or vegetable substances in a state of decomposition, and certain saline ingredients. The earthy matters are the true basis of the soil; the other parts, whether natural, or artificially introduced, operate in the same manner as manures. Four earths generally abound in soils; the aluminous, the silicious, the calcareous, and the magnesian. These earths, as I have discovered, consist of highly inflammable metals united to pure air, or oxygen; and they are not, as far as we know, decomposed or altered in vegetation.

The great use of the soil is to afford support to the plant, to enable it to fix its roots, and to derive nourishment by its tubes slowly and gradually, from the soluble and dissolved substances mixed with the earths.

That a particular mixture of the earths is connected with fertility, cannot be doubted: and almost all steril soils are capable of being improved, by a modification of their earthy constituent parts. I shall describe the simplest method as yet discovered of analysing soils, and of ascertaining the constitution and chemical ingredients which appear to be connected with fertility; and on this subject many of the former difficulties of investigation will be found to be removed by recent inquiries.

The necessity of water to vegetation, and the luxuriancy of the growth of plants connected with the presence of moisture in the southern countries of the old continent, led to the opinion so prevalent in the early schools of philosophy, that water was the great productive element, the substance from which all things were capable of being composed, and into which they were finally resolved. The "*ariston men hydor*" of the poet, "water is the noblest," seems to have been an expression of this opinion, adopted by the Greeks from the Egyptians, taught by Thales, and revived by the alchemists in late times. Van Helmont, in 1610, conceived that he had proved, by a decisive experiment, that all the products of vegetables were capable of being generated from water. His results were shown to be fallacious by Woodward in 1691; but the true use of water in vegetation was unknown till 1785; when Mr. Cavendish made the discovery, that it was composed of two elastic fluids or gases, inflammable gas or hydrogen, and vital gas or oxygen.

Air, like water, was regarded as a pure element by most of the ancient philosophers: a few of the chemical inquirers in the sixteenth and seventeenth centuries, formed some happy conjectures respecting its real nature. Sir Kenelm Digby, in 1660, supposed that it contained some saline matter, which was an essential food of plants. Boyle, Hook, and Mayow, between 1665 and 1680, stated, that a small part of it only was consumed in the respiration of animals, and in the combustion of inflammable bodies; but the true statical analysis of the atmosphere is comparatively a recent labor, achieved towards the end of the last century by Scheele, Priestley, and Lavoisier. These celebrated men showed that its principal elements are two gases, oxygen and azote, of which the first is essential to flame, and to the life of animals and that it likewise contains small quantities of aqueous vapor, and of carbonic acid gas; and Lavoisier proved that this last body is itself a compound elastic fluid, consisting of charcoal dissolved in oxygen.

Jethro Tull, in his Treatise on Horse-hoeing, published in 1733, advanced the opinion, that minute earthy particles supplied the whole nourishment of the vegetable world; that air and water were chiefly useful in producing these particles from the land; and that manures acted in no other way than in ameliorating the texture of the soil, in short, that their agency was mechanical. This ingenious author of the new system of agriculture having observed the excellent effects produced in farming, by a minute division of the soil, and the pulverization of it by exposure to dew and air, was misled, by carrying his principles too far. Duhamel, in a work printed in 1754, adopted the opinion of Tull; and stated, that by finely dividing the soil, any number of crops might be raised in succession from the same land. He attempted also to prove, by direct experiments, that vegetables of every kind were capable of being raised without manure. This celebrated horticulturist lived, however, sufficiently long to alter his opinion. The results of his later and most refined observations led him to the conclusion, that no single material afforded the food of plants. The general experience of farmers had long before convinced the unprejudiced of the truth of the same opinion, and that manures were absolutely consumed in the process of vegetation. The exhaustion of soils, by carrying off corn crops from them, and the effects of feeding cattle on lands, and of preserving their manure, offer familiar illustrations of the principle; and several philosophical inquirers, particularly Hassenfratz and Saussure, have shown, by satisfactory experiments, that animal and vegetable matters deposited in soils are absorbed by plants, and become a part of their organized matter. But though neither water, nor air, nor earth, supplies the whole of the food of plants, yet they all operate in the process of vegetation. The soil is the laboratory in which the food is prepared. No manure can be taken up by the roots of plants, unless water is present; and water, or its elements, exist in all the products of vegetation. The germination of seeds does not take place without the presence of air or oxygen gas: and in the sunshine, vegetables decompose the carbonic acid gas of the atmosphere, the carbon of which is absorbed, and becomes a part of their organized matter, and the oxygen gas, the other constituent, is given off;* and, in consequence of a variety of agencies, the economy of vegetation is made subservient to the general order of the system of nature.

It is shown by various researches, that the constitution of the atmosphere has been always the same since the time that it was first accurately analyzed; and this must, in a great measure, de-

* The great accumulation of carbon in forests and in peat mosses, not to lay stress on beds of mineral coal, which there is good reason to consider of vegetable origin, affords demonstrative proof, as it appears to me, of the truth in the text, that plants, in active vegetation and growth, either mediately or immediately derive from the atmosphere carbon, by the decomposition of carbonic acid and the liberation of its oxygen. J. D.

pend upon the powers of plants to absorb or decompose the putrefying or decaying remains of animals and vegetables, and the gaseous effluvia which they are constantly emitting. Carbonic acid gas is formed in a variety of processes of fermentation and combustion, and in the respiration of animals; and, as yet, no other process is known in nature by which it can be consumed, except vegetation. Animals produce a substance which appears to be a necessary food of vegetables; vegetables evolve a principle necessary to the existence of animals; and these different classes of beings seem to be thus connected together in the exercise of their living functions, and to a certain extent made to depend upon each other for their existence. Water is raised from the ocean, diffused through the air, and poured down upon the soil, so as to be applied to the purposes of life. The different parts of the atmosphere are mingled together by winds or changes of temperature, and successively brought in contact with the surface of the earth, so as to exert their fertilizing influence. The modifications of the soil, and the application of manures, are placed within the power of man, as if for the purpose of awakening his industry, and of calling forth his powers.

The theory of the general operation of the more compound manures, may be rendered very obvious by simple chemical principles; but there is still much to be discovered, with regard to the best methods of rendering animal and vegetable substances soluble; with respect to the processes of decomposition, how they may be accelerated or retarded, and the means of producing the greatest effects from the materials employed: these subjects will be attended to in the lecture on manures.

Plants are found by analysis to consist principally of charcoal and aëriform matter. They give out by distillation volatile compounds, the elements of which are pure air, inflammable air, coally matter, and azote, or that elastic substance which forms a great part of the atmosphere, and which is incapable of supporting combustion. These elements they gain, either by their leaves from the air, or by their roots from the soil. All manures from organized substances contain the principles of vegetable matter, which, during putrefaction, are rendered either soluble in water or aëriform—and in these states, they are capable of being assimilated to the vegetable organs. No one principle affords the pabulum of vegetable life; it is neither charcoal nor hydrogen, nor azote, nor oxygen alone; but all of them together, in various states and various combinations. Organic substances, as soon as they are deprived of vitality, begin to pass through a series of changes, which ends in their complete destruction, in the entire separation and dissipation of the parts. Animal matters are the soonest destroyed by the operation of air, heat, and light. Vegetable substances yield more slowly, but finally obey the same laws.* The periods of the application of manures from decomposing animal and vegetable substances depend upon the knowledge of these principles; and I shall be able to produce some new and important facts founded upon them, which I trust will remove all doubt from this part of agricultural theory.

The chemistry of the more simple manures, the manures which act in very small quantities, such as gypsum, alkalies, and various saline substances, has hitherto been exceedingly obscure. It has been generally supposed that these materials act in the vegetable economy in the same manner as condiments or stimulants in the animal economy, and that they render the common food more nutritive. It seems, however, a much more probable idea, that they are actually a part of the true food of plants, and that they supply that kind of matter to the vegetable fibre, which is analogous to the bony matter in animal structures.

The operation of gypsum, it is well known, is extremely capricious in this country, and no certain data have hitherto been offered for its application. There is, however, good ground for supposing that the subject will be fully elucidated by chemical inquiry. Those plants which seem most benefited by its application are plants which always afford it on analysis. Clover, and most of the artificial grasses, contain it; but it exists in very minute quantity only in barley, wheat, and turnips. Many peat ashes, which are sold at a considerable price, consist in great part of gypsum, with a little iron; and the first seems to be their most active ingredient. I have examined several of the soils to which these ashes are successfully applied, and I have found in them no sensible quantity of gypsum. In general, cultivated soils contain sufficient of this substance for the use of the grasses; in such cases, its application cannot be advantageous. For plants require only a certain quantity of manure; an excess may be detrimental, and cannot be useful.

The theory of the operation of alkaline substances is one of the parts of the chemistry of agriculture most simple and distinct. They are found in all plants, and therefore may be regarded as amongst their essential ingredients. From their powers of combination, likewise, they may be useful in introducing various principles into the sap of vegetables, which may be subservient to their nourishment.

The fixed alkalies, which were formerly regarded as elementary bodies, it has been my good fortune to decompose. They consist of pure air, united to highly inflammable metallic substances; but there is no reason to suppose that they are reduced into their elements in any of the processes of vegetation.

In this part of the course I shall dwell at considerable length on the important subject of lime, and I shall be able to offer some novel views.

Slacked lime was used by the Romans for manuring the soil in which fruit-trees grew. This we are informed by Pliny. Marl had been employed by the Britons and the Gauls from the earliest times, as a top-dressing for land. But the precise period in which burnt lime first came into general use in the cultivation of land, is, I believe, unknown. The origin of the application from the early practices is sufficiently obvious; a substance, which had been used with success in gardening, must have been soon tried in farming; and in

* This statement in the text, though correct generally, is not without exception. Some vegetable substances undergo change very rapidly; some animal substances very slowly. The expressed juices of most fruits enter into the vinous fermentation as rapidly, or even more rapidly, at the temperature of 70° Fahr. than the animal fluids do the putrefactive; the white tissues of animals, as tendons, &c. resist change with great pertinacity.—J. D.

countries where marl was not to be found, calcined limestone would be naturally employed as a substitute.

The elder writers on agriculture had no correct notions of the nature of lime, limestone, and marl, or of their effects; and this was the necessary consequence of the imperfection of the chemistry of the age. Calcareous matter was considered by the alchemists as a peculiar earth, which, in the fire became combined with inflammable acid; and Evelyn and Hartlib, and, still later, Lisle, in their works on husbandry, have characterized it merely as a hot manure, of use in cold lands. It is to Dr. Black, of Edinburgh, that our first distinct rudiments of knowledge on the subject are owing About the year 1755, this celebrated professor proved, by the most decisive experiments, that limestone and all its modifications, marbles, chalks, and marls, consist principally of a peculiar earth united to an aërial acid: that the acid is given out in burning, occasioning a loss of more than 40 per cent., and that the lime in consequence becomes caustic.

These important facts immediately applied, with equal certainity, to the explanation of the uses of lime, both as a cement and as a manure. As a cement, lime, applied in its caustic state, acquires its hardness and durability, by absorbing the aërial (or, as it has been since called, carbonic) acid, which always exists in small quantities in the atmosphere; it becomes, as it were, again limestone.

Chalks, calcareous marls, or powdered limestones, act merely by forming an useful earthy ingredient of the soil, and their efficacy is proportioned to the deficiency of calcareous matter, which, in larger or smaller quantities, seems to be an essential ingredient of all fertile soils; necessary, perhaps, to their proper texture, and as an ingredient in the organs of plants.

Burnt lime, in its first effect, acts as a decomposing agent upon animal or vegetable matter, and seems to bring it into a state in which it becomes more rapidly a vegetable nourishment; gradually, however, the lime is neutralized by carbonic acid, and converted into a substance analogous to chalk; but in this case it more perfectly mixes with the other ingredients of the soil, is more generally diffused and finely divided; and it is probably more useful to land than any calcareous substance in its natural state.

The most considerable fact made known, with regard to limestone, within the last few years, is owing to Mr. Tennant. It had been long known, that a particular species of limestone, found in different parts of the north of England, when applied in its burnt and slacked state to land in considerable quantities, occasioned sterility, or considerably injured the crops for many years. Mr. Tennant in 1800, by a chemical examination of this species of limestone, ascertained that it differed from common limestones by containing magnesian earth; and by several experiments he proved, that this earth was prejudicial to vegetation, when applied in large quantities in its caustic state. Under common circumstances, the lime from the magnesian limestone is, however, used in moderate quantities upon fertile soils in Leicestershire, Derbyshire, and Yorkshire, with good effect; and it may be applied in greater quantities to soils containing very large proportions of vegetable matter. Magnesia, when combined with carbonic acid gas seems not to be prejudicial to vegetation, and in soils rich in manure it is speedily supplied with this principle from the decomposition of the manure.

After the nature and operation of manures have been discussed, the next, and the last subject for our consideration, will be some of the operations of husbandry capable of elucidation by chemical principles.

The chemical theory of fallowing is very simple. Fallowing affords a source of riches to the soil, in consequence of the absorption of oxygen and the aqueous principles of the atmosphere, and so tends to produce an accumulation of decomposing matter, which, in the common course of crops, would be employed as it is formed. Yet in highly cultivated soils, under a regular succession of crops, properly manured, this practice can rarely be advantageous: and the cases in which it is really beneficial are for the destruction of weeds, and for cleansing foul soils.

The chemical theory of paring and burning, I shall discuss fully in this part of the course.

It is obvious, that in all cases it must destroy a certain quantity of vegetable matter, and must be principally useful in cases in which there is an excess of this matter in soils. Burning, likewise, renders clays less coherent, and in this way greatly improves their texture, and causes them to be less permeable to water.

The instances in which it must be obviously prejudicial are those of sandy, dry siliceous soils, containing little animal or vegetable matter. Here it can only be destructive, for it decomposes that on which the soil depends for its productiveness.

The advantages of irrigation, though so lately a subject of much attention, were well known to the ancients; and more than two centuries ago the practice was recommended to the farmers of our country by Lord Bacon: "meadow-watering," according to the statements of this illustrious personage, (given in his Natural History, in the article Vegetation,) "acts not only by supplying useful moisture to the grass; but likewise the water carries nourishment dissolved in it, and defends the roots from the effects of cold."

No general principles can be laid down respecting the comparative merit of the different systems of cultivation and the various systems of crops adopted in different districts, unless the chemical nature of the soil, and the physical circumstances to which it is exposed, are fully known. Stiff coherent soils are those most benefited by minute division and aëration, and in the drill system of husbandry these effects are produced to the greatest extent; but still the labor and expense connected with its application in certain districts may not be compensated for by the advantages produced, and there are some stiff soils which must be left in clods when sown with wheat. Moist climates are best fitted for raising the artificial grasses, oats, and broad-leaved crops; stiff aluminous soils, in general, are most adapted for wheat crops, and calcareous soils produce excellent sain-foin and clover.

Nothing is more wanting in agriculture than experiments in which all the circumstances are minutely and scientifically detailed. This art will advance with rapidity in proportion as it becomes exact in its methods. As in physical researches, all the causes should be considered; a difference

in the results may be produced, even by the fall of a half an inch of rain more or less in the course of a season, or a few degrees of temperature, or even by a slight difference in the sub-soil, or in the inclination of the land.

Information collected after views of distinct inquiry would necessarily be fitted for inductive reasoning, and capable of being connected with the general principles of science; and a few histories of the results of truly philosophical experiments in agricultural chemistry would be of more value in enlightening and benefiting the farmer, than the greatest possble accumulation of imperfect trials conducted merely in the empirical spirit. It is no unusual occurrence for persons who argue in favor of practice and experience, to condemn generally all attempts to improve agriculture by philosophical inquiries and chemical methods. That much vague speculation may be found in the works of those who have lightly taken up agricultural chemistry, it is impossible to deny. It is not uncommon to find a number of changes rung upon a string of technical terms, such as oxygen, hydrogen, carbon, and azote, as if the science depended upon words rather than upon things. But this is, in fact, an argument for the necessity of the establishment of just principles of chemistry on the subject. Whoever reasons upon agriculture is obliged to recur to this science. He feels that it is scarcely possible to advance a step without it; and if he is satisfied with insufficient views, it is not because he prefers them to accurate knowledge, but generally because they are more current. If a person journeying in the night wishes to avaid being led astray by the ignis fatuus, the most secure method is to carry a lamp in his own hand.

It has been said, and undoubtedly with great truth, that a philosophical chemist would most probably make a very unprofitable business of farming; and this certainly would be the case, if he were a mere philosophical chemist; and unless he had served his apprenticeship to the practice of the art as well as to the theory.* But there is reason to believe that he would be a more successful agriculturist than a person equally uninitiated in farming, but ignorant of chemistry altogether; his science, as far as it went, would be useful to him. But chemistry is not the only kind of knowledge required; it forms a small part of the philosophical basis of agriculture; but it is an important part, and, whenever applied in a proper manner, must produce advantages.

In proportion as science advances, all the principles become less complicated, and consequently more useful. And it is then that their application is most advantageously made to the arts. The common laborer can never be enlightened by the general doctrines of philosophy, but he will not refuse to adopt any practice, of the utility of which he is fully convinced, because it has been founded upon these principles. The mariner can trust to the compass, though he may be wholly unacquainted with the discoveries of Gilbert on magnetism, or the refined principles of that science developed by the genius of Æpinus. The dyer will use his bleaching liquor, even though he is perhaps ignorant not only of the constitution, but even of the name of the substance on which its powers depend. The great purpose of chemical investigation in agriculture ought undoubtedly to be, the discovery of improved methods of cultivation, But to this end general scientific principles and practical knowledge are alike necessary. The germs of discovery are often found in rational speculations; and industry is never so efficacious as when assisted by science.

It is from the higher classes of the community, from the proprietors of land; those who are fitted, by their education, to form enlightened plans, and by their fortunes, to carry such plans into execution: it is from these that the principles of improvement must flow to the laboring classes of the community; and in all cases the benefit is mutual; for the interest of the tenantry must be always likewise the interest of the proprietors of the soil. The attention of the laborer will be more minute, and he will exert himself more for improvement, when he is certain he cannot deceive his employer, and has a conviction of the extent of his knowledge. Ignorance in the possessor of an estate, of the manner in which it ought to be treated, generally leads either to inattention, or injudicious practices in the tenant or the bailiff. "*Agrum pessimum mulctari cujus Dominus non docet sed audit villicum.*"

There is no idea more unfounded than that a great devotion of time, and a minute knowledge of general chemistry, is necessary for pursuing experiments on the nature of soils, or the properties of manures. Nothing can be more easy than to discover whether a soil effervesces, or changes color by the action of an acid, or whether it burns when heated, or what weight it loses by heat; and yet these simple indications may be of great importance in a system of cultivation. The expense connected with chemical inquiries is extremely trifling; a small closet is sufficient for containing all the materials required. The most important experiments may be made by means of a small portable apparatus; a few phials, containing acids, alkalies, and chemical re-agents; some foil and wire of platinum; a lamp, a crucible, some filtrating paper, some funnels and glasses, for receiving products, are all that can be considered as absolutely essential for pursuing useful researches.

It undoubtedly happens in agricultural chemical experiments conducted after the most refined theoretical views, that there are many instances of failure for one of success; and this is inevitable from the capricious and uncertain nature of the causes that operate, and from the impossibility of calculating on all the circumstances that may interfere: but this is far from proving the inutility of such trials; one happy result, which can generally improve the methods of cultivation, is worth the labor of a whole life; and an unsuccessful experiment, well observed, must establish some truth, or tend to remove some prejudice.

Even considered merely as a philosophical science, this department of knowledge is highly worthy of cultivation. For what can be more delightful than to trace the forms of living beings

*Lavoisier is a remarkable example of the advantages which may be derived from the applicaton of science to agriculture, even without a minute knowledge of the art of farming. By following an enlightened system, he is said to have doubled in nine years the produce in grain of his land, whilst he quintupled the number of his flocks.—*Notice sur Lavoisier*, in *Bibliotheque du chimiste*, tom, vii. p. 121.—J. D.

and their adaptations and peculiar purposes; to examine the progress of inorganic matter in its different processes of change, till it attain its ultimate and highest destination,—its subserviency to the purposes of man?

Many of the sciences are ardently pursued, and considered as proper objects of study for all refined minds, merely on account of the intellectual pleasure they afford; merely because they enlarge our views of nature, and enable us to think more correctly with respect to the beings and objects surrounding us. How much more, then, is this department of inquiry worthy of attention, in which the pleasure resulting from the love of truth and of knowledge is as great as in any other branch of philosophy, and in which it is likewise connected with much greater practical benefits and advantages? "*Nihil est melius, nihil uberius, nihil homine libero dignius.*"

Discoveries made in the cultivation of the earth are not merely for the time and country in which they are developed, but they may be considered as extending to future ages, and as ultimately tending to benefit the whole human race; as affording subsistence for generations yet to come; as multiplying life, and not only multiplying life, but likewise providing for its enjoyment.

LECTURE II.

OF THE GENERAL POWERS OF MATTER WHICH INFLUENCE VEGETATION. OF GRAVITATION, OF COHESION, OF CHEMICAL ATTRACTION, OF HEAT, OF LIGHT, OF ELECTRICITY, PONDERABLE SUBSTANCES, ELEMENTS OF MATTER, PARTICULARLY THOSE FOUND IN VEGETABLES, LAWS OF THEIR COMBINATIONS AND ARRANGEMENTS.

The great operations of the farmer are directed towards the production or improvement of certain classes of vegetables; they are either mechanical or chemical, and are, consequently, dependent upon the laws which govern common matter. Plants themselves are, to a certain extent, submitted to these laws; and it is necessary to study their effects, both in considering the phenomena of vegetation, and the cultivation of the vegetable kingdom.

One of the most important properties belonging to matter is *gravitation*, or the power by which masses of matter are attracted towards each other. It is in consequence of gravitation that bodies thrown inio the atmosphere fall to the surface of the earth, and that the different parts of the globe are preserved in their proper positions. Gravity is exerted in proportion to the quantity of matter. Hence all bodies placed above the surface of the earth fall to it in right lines, which, if produced, would pass through its centre; and a body falling near a high mountain is a little bent out of the perpendicular direction by the attraction of the mountain, as has been shown by the experiments of Dr. Maskelyne on Schehallien.

Gravitation has a very important influence on the growth of plants; and it is rendered probable, by the experiments of Mr. Knight, that they owe the peculiar direction of their roots and branches almost entirely to this force.

That gentleman fixed some seeds of the garden bean on the circumference of a wheel, which in one instance was placed vertically, and in the other horizontally, and made to revolve, by means of another wheel worked by water, in such a manner, that the number of the revolutions could be regulated; the beans were supplied with moisture, and were placed under circumstances favorable to germination. The beans all grew, notwithstanding the violence of revolution, which was sometimes as much as 250 revolutions in a minute on the vertical wheel, which always revolved rapidly, and with little variation of velocity; the radicles, or roots, pointed precisely in the direction of radii in whatever direction they were first placed. The germs took precisely the opposite direction, and pointed to the centre of the wheel, where they soon met each other. Upon the horizontal wheel, the conflicting operation of gravitation and centrifugal force, occasioned the germs to form a cone, more or less obtuse, according to the velocity of the wheel, the radicles always taking a course diametrically opposite to that taken by the germs, and, consequently, pointing as much below as the germs pointed above the plane of the wheel's motion.

These facts afford a rational solution of this curious problem, respecting which different philosophers have given such different opinions; some referring it to the nature of the sap, as De la Hire; others, as Darwin, to the living powers of the plant, and the stimulus of air upon the leaves, and of moisture upon the roots. The effect is now shown to be connected with mechanical causes; and there seems no other power in nature to which it can with propriety be referred, but gravity, which acts universally, and which must tend to dispose the parts to take a uniform direction.*

If plants in general owe their perpendicular direction to gravity, it is evident that the number of plants upon a given part of the earth's circumference cannot be increased by making the surface irregular, as some persons have supposed. Nor can more stalks rise on a hill than on a spot equal to its base; for the slight effect of the attraction of the hill, would be only to make the plants deviate a very little from the perpendicular. Where horizontal layers are pushed forth, as in certain grasses, particularly such as the fiorin, lately brought into notice by Dr. Richardson, more food may, however, be produced upon an irregular surface; but the principle seems to apply strictly to corn crops.

The direction of the radicles and germens is such, that both are supplied with food, and acted upon by those external agents which are necessary for their developement and growth. The roots come in contact with the fluids in the ground; the leaves are exposed to light and air; and the same grand law which preserves the planets in their orbits is thus essential to the functions of vegetable life.

When two pieces of polished glass are pressed together, they adhere to each other, and it requires some force to separate them. This is said to depend upon the *attraction of cohesion*. The same

* Fig. 1. represents the case in which the horizontal wheel performed 250 revolutions.

Fig. 2. represents the form of the experiment when the vertical wheel was made to perform 150 revolutions in a minute.

Fig. 1.

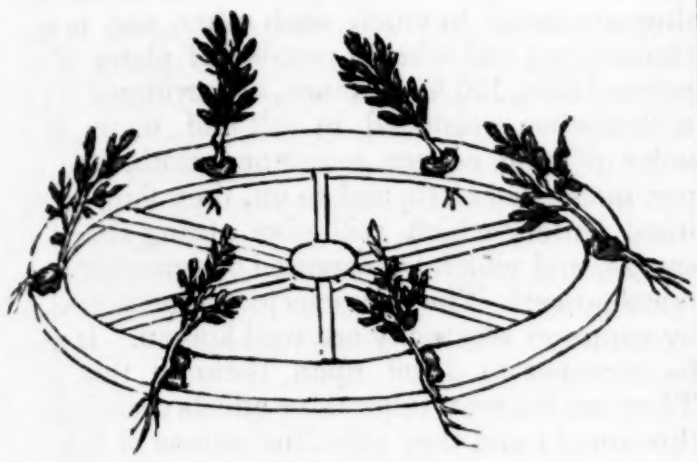
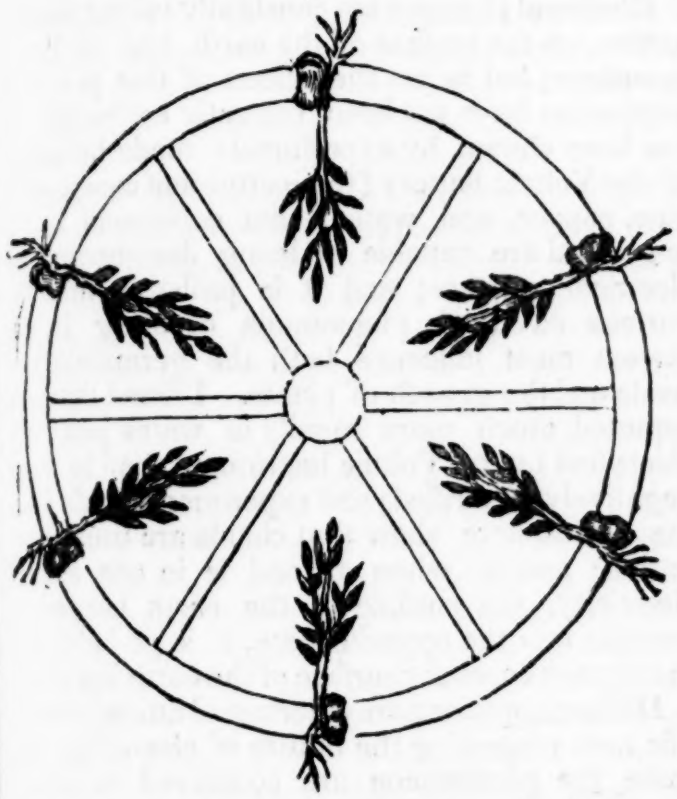


Fig. 2.



attraction gives the globular form to drops of water, and enables fluids to rise in capillary tubes; and hence it is sometimes called *capillary attraction*. This attraction, like gravitation, seems common to all matter, and may be a modification of the same general force; like gravitation, it is of great importance in vegetation. It preserves the forms of aggregation of the parts of plants, and it seems to be a principal cause of the absorption of fluids by their roots.

If some pure magnesia, the calcined magnesia of druggists, be thrown into distilled vinegar, it gradually dissolves. This is said to be owing to *chemical attraction*, the power by which different species of matter tend to unite into one compound. Various kinds of matter unite with different degrees of force: thus sulphuric acid and magnesia unite with more readiness than distilled vinegar and magnesia; and if sulphuric acid be poured into a mixture of vinegar and magnesia, in which the acid properties of the vinegar have been destroyed by the magnesia, the vinegar will be set free, and the sulphuric acid will take its place. This chemical attraction is likewise called *chemical affinity*. It is active in most of the phenomena of vegetation. The sap consists of a number of ingredients, dissolved in water by chemical attraction; and it appears to be in consequence of the operation of this power, that certain principles derived from the sap are united to the vegetable organs. By the laws of chemical attraction, different products of vegetation are changed, and assume new forms: the food of plants is prepared in the soil; vegetable and animal remains are changed by the action of air and water, and made fluid or aëriform; rocks are broken down and converted into soils; and soils are more finely divided and fitted as receptacles for the roots of plants.

The different powers of attraction tend to preserve the arrangements of matter, or to unite them in new forms. If there were no opposing powers there would soon be a state of perfect quiescence in nature, a kind of eternal sleep in the physical world. Gravitation is continually counteracted by mechanical powers, by projectile motion, or the centrifugal force; and their joint agencies occasion the motion of the heavenly bodies. Cohesion and chemical attraction are opposed by the *repulsive energy* of *heat*, and the harmonious cycle of terrestrial changes is produced by their mutual operations.

Heat is capable of being communicated from one body to other bodies; and its common effect is to expand them, to enlarge them in all their dimensions. This is easily exemplified. A solid cylinder of metal after being heated will not pass through a ring barely sufficient to receive it when cold. When water is heated in a globe of glass having a long slender neck, it rises in the neck; and if heat be applied to air confined in such a vessel inverted above water, it makes its escape from the vessel and passes through the water. Thermometers are instruments for measuring degrees of heat by the expansion of fluids in narrow tubes. Mercury is generally used, of which 100,000 parts at the freezing point of water become 101,835 parts at the boiling point, and on Fahrenheit's scale these parts are divided into 180 degrees. Solids, by a certain increase of heat, become fluids, and fluids gases; or elastic fluids. Thus ice is converted by heat into water, and by still more heat it becomes steam; and heat disappears, or, as it is called, is rendered *latent*, during the conversion of solids into fluids, or fluids into gases, and re-appears, or becomes sensible, when gases become fluids, or fluids solids; hence cold is produced during evaporation, and heat during the condensation of steam.

There are a few exceptions to the law of expansion of bodies by heat, which seem to depend either upon some change in their chemical constitution, or on their becoming crystallised. Clay contracts by heat, which seems to be owing to its giving off water. Cast iron and antimony, when melted, crystallise, in cooling, and expand. Ice is much lighter than water. Water expands a little even before it freezes, and it is of the greatest density at about 41° or 42°, the freezing point being 32°; and this circumstance is of considerable importance in the general economy of nature. The influence of the changes of seasons and of the position of the sun on the phenomena of vegetation demonstrates the effects of heat on the functions of plants. The matter absorbed from the soil must be in a fluid state to pass into their roots, and when the surface is frozen they can derive no nourishment from it. The activity of chemical changes likewise is increased by a certain increase of temperature, and even the rapidity of the ascent of fluids by capillary attraction.

This last fact is easily shown by placing in each of two wine glasses a similar hollow stalk of grass, so bent as to discharge any fluid in the glasses slowly by capillary attraction: if hot water

be in one glass, and cold water in the other, the hot water will be discharged much more rapidly than the cold water. The fermentation and decomposition of animal and vegetable substances require a certain degree of heat, which is consequently necessary for the preparation of the food of plants; and, as evaporation is more rapid in proportion as the temperature is higher, the superfluous parts of the sap are most readily carried off at the time its ascent is quickest.

Two opinions are current respecting the nature of heat. By one School it is conceived to be a peculiar subtile fluid, of which the particles repel each other, but have a strong attraction for the particles of other matter. By another it is considered as a motion or vibration of the particles of matter, which is supposed to differ in velocity in different cases, and thus to produce the different degrees of temperature. Whatever decision be ultimately made respecting these opinions, it is certain that there is matter moving in the space between us and the heavenly bodies capable of communicating heat; the motions of which are rectilinear: thus the solar rays produce heat in acting on the surface of the earth. The experiments of Sir W. Herschel have shown that the calorific effects of the solar rays bear no relation to their illuminating powers, the red rays producing a much greater effect of heat than any of the other colored rays; and it appears that there are *invisible* rays distinguished by very different degrees of refrangibility, some of which produce *heat*, and others of which are distinguished by their *chemical* effects.

The different influence of the different solar rays on vegetation have not yet been studied; but it is certain that the rays exercise an influence independent of the heat they produce. Thus plants kept in the dark in a hot-house grow luxuriantly, but they never gain their natural colors; their leaves are white or pale, and their juices watery and peculiarly saccharine.

The earth, when not exposed to the solar rays, is constantly losing heat by radiation, and different soils have their temperature differently diminished by this cause.

When a piece of sealing-wax is rubbed by a woollen cloth, it gains the power of attracting light bodies, such as feathers or ashes. In this state it is said to be *electrical;* and if a metallic cylinder, placed upon a rod of glass, is brought in contact with the sealing-wax, it likewise gains the momentary power of attracting light bodies, so that electricity, like heat, is communicable. When two light bodies receive the same electrical influence, or are electrified by the same body, they repel each other. When one of them is acted on by sealing-wax, and the other by glass that has been rubbed by woollen, they attract each other; hence it is said that bodies similarly electrified repel each other: and bodies dissimilarly electrified attract each other: and the electricity of glass is called vitreous or positive electricity, and that of sealing-wax, resinous or negative electricity.

When, of two bodies made to rub each other, one is found positively electrified, the other is always found negatively electrified, and, as in the common electrical machine, these states are capable of being communicated to metals placed upon rods or pillars of glass. Electricity is produced likewise by the contact of bodies; thus a piece of zinc and of silver give a slight electrical shock when they are made to touch each other, and to touch the tongue; and when a number of plates of copper and zinc, 100 for instance, are arranged in a pile with clothes moistened in salt and water, in the order of zinc, copper, moistened cloth, zinc, copper, moistened cloth, and so on, they form an electrical battery which will give strong shocks and sparks, and which is possessed of remarkable chemical powers. The luminous phenomena produced by common electricity are well known. It would be improper to dwell upon them in this place. They are the most impressive effects occasioned by this agent; and they offer illustrations of lightning and thunder.

Electrical changes are constantly taking place in nature, on the surface of the earth, and in the atmosphere; but as yet the effects of this power in vegetation have not been correctly estimated. It has been shown by experiments made by means of the Voltaic battery (the instrument composed of zinc, copper, and water) that compound bodies in general are capable of being decomposed by electrical powers; and it is probable that the various electrical phenomena occuring in our system must influence both the germination of seeds and the growth of plants. I found that corn sprouted much more rapidly in water positively electrified by the Voltaic instrument than in water negatively electrified; and experiments made upon the atmosphere show that clouds are usually negative; and as, when a cloud is in one state of electricity, the surface of the earth beneath is brought into the opposite state, it is probable that in common cases the surface of the earth is positive.

Different opinions are entertained amongst scientific men respecting the nature of electricity. By some the phenomena are conceived to depend upon a single subtile fluid in excess in the bodies said to be positively electrified, in deficiency in the bodies said to be negatively electrified. A second class suppose the effects to be produced by two different fluids, called by them the vitreous fluid and the resinous fluid; and an hypothesis has been advanced in which they are considered as affections or motions of matter, or an exhibition of attractive powers, similar to those which produce chemical combination and decomposition; but usually exerting their action on masses.*

The power which gives to a bar or needle of steel the property of directing itself to two points of the globe, called north and south poles, depends upon what is called magnetism. It agrees with electricity in many of its laws; but, as far as our researches have hitherto gone, it is most active in its operation on metals and certain of their combinations. Iron, nickel, and cobalt, are most susceptible of magnetic impressions, and in the harder compounds of iron these impressions produce permanent effects; but the recent experiments of M. Arago show, that copper, metals in general, and,

*In a series of experiments on the electricity of the atmosphere, made in Malta during the course of several months, I had ample proof of the truth of the above opinion. Chemical effects were almost constantly taking place, even in serene weather, in a very slight degree. The subject of the experiment was commonly the gelatinous compound of the iodide of potassium and starch; and almost invariably, excepting occasionally in thunder-storms, the iodine was precipitated round the platina wire connected with the earth.—J. D.

probably, all other substances, receive very weak and evanescent magnetism, which seems to differ in intensity for every body. Magnetism is capable of being communicated from bodies endowed with it, to others that do not possess it, and is produced whenever concentrated electricity passes through space, its sphere of action or communication being at right angles to the course of the electricity. Thus a bar of steel, placed transversely over a wire conveying an electrical shock, becomes a magnet. The connexion of magnetism and electricity is of recent discovery, and the fact which served to established it was made known by M. Œrsted, a Danish philosopher. It will ultimately probably tend to a more intimate acquaintance with the nature of these two extraordinary agents. The attractive powers of the magnet may be made use of to show the existence of iron in soils, as will be mentioned more particularly hereafter.

The different powers that have been thus generally described continually act upon common matter so as to change its form, and produce arrangements fitted for the purposes of life. Bodies are either simple or compound. A body is said to be simple, when it is incapable of being resolved into any other forms of matter. Thus, gold or silver, though they may be melted by heat, or dissolved in corrosive menstrua, yet are recovered unchanged in their properties, and they are said to be simple bodies. A body is considered as compound, when two or more distinct substances are capable of being produced from it: thus marble is a compound body, for by a strong heat it is converted into lime, and an elastic fluid is disengaged in the process; and the proof of our knowledge of the true composition of a body is, that it is capable of being reproduced by the same substances as those into which it had been decomposed; thus, by exposing lime for a long while to the elastic fluid disengaged during its calcination, it becomes converted into a substance similar to powdered marble. The term element has the same meaning as simple or undecompounded body; but it is applied merely with reference to the present state of chemical knowledge. It is probable that, as yet, we are not acquainted with any of the true elements of matter: many substances, formerly supposed to be simple, have been lately decompounded, and the chemical arrangement of bodies must be considered as a mere expression of facts, the results of accurate statical experiments.

Vegetable substances in general are of a very compound nature, and consist of a great number of elements, most of which belong likewise to the other kingdoms of nature, and are found in various forms. Their more complicated arrangements are best understood after their simpler forms of combination have been examined.

The number of bodies which I shall consider as at present undecomposed, are, as was stated in the introductory lecture, five acidifying or solvent substances, eight inflammable bodies, and forty metals.*

In most of the inorganic compounds, the nature of which is well known, into which these elements enter, they are combined in definite proportions; so that, if the elements be represented by numbers, the proportions in which they combine are expressed either by those numbers, or by some simple multiples of them.

* Now forty-two.—*Vide note, ante.*

I shall mention, in a few words, the characteristic properties of the most important simple substances, and the numbers representing the proportions in which they combine in those cases where they have been accurately ascertained.

1. *Oxygen* forms about one-fifth of the air of our atmosphere. It is an elastic fluid, at all known temperatures. Its specific gravity is to that of air as 10,967 to 10,000. It supports combustion with much more vividness than common air; so that if a small steel wire or a watch-spring, having a bit of inflamed wood attached to it, be introduced into a bottle filled with the gas, it burns with great splendor. It is respirable. It is very slightly soluble in water. The number representing the proportion in which it combines is 15. It may be made by heating a mixture of the mineral called manganese and sulphuric acid together in a proper vessel, or by heating strongly red lead, or red precipitate of mercury.

2. *Chlorine* is, like oxygen, a permanent elastic fluid. Its color is yellowish green; its smell is very disagreeable; it is not respirable; it supports the combustion of all the common inflammable bodies except charcoal; its specific gravity is to that of air as 24,677 to 10,000; it is soluble in about half its volume of water, and its solution in water destroys vegetable colors. Many of the metals (such as arsenic or copper) take fire spontaneously when introduced into a jar or bottle filled with the gas. Chlorine may be procured by heating together a mixture of spirits of salt, or muriatic acid, and manganese. The number representing the proportion in which this gas enters into combination is 67.

3. *Fluorine*, or the fluoric principle. This substance has such strong tendencies to combination, that as yet no vessels have been found capable of containing it in its pure form. It may be obtained, combined with hydrogen, by applying heat to a mixture of fluor, or Derbyshire spar, and sulphuric acid; and in this state it is an intensely acid compound, a little heavier than water, and which becomes still denser by combining with water. The existence of fluorine as an element is proved by its expulsion from certain compounds by chlorine, and by its transference from place to place. In attempts made to confine it, so as to examine its properties, it always combines with, or decomposes the vessels employed; so that, as yet, its physical qualities are unknown: 16 is an approximation to the number representing it.

4. *Iodine.* This substance is procured from the ashes of marine plants, after the extraction of the carbonate of soda, by acting upon them by sulphuric acid. It appears as a dark-colored solid, having the color and lustre of plumbago: its specific gravity is about 4; that of water being 1. It fuses at a low temperature, and at a heat above that of boiling water becomes a violet-colored gas. It forms an active acid by uniting to hydrogen. The alkaline metals burn, when heated in it. It unites to all the metals upon which its action has been examined.

5. *Brome.* This body has been very recently discovered in sea-water. It is in its nature analogous to iodine, and resembles a compound of these two bodies. It is a dense liquid, and forms an orange-colored gas by a gentle heat.

6. *Hydrogen*, or inflammable air, is the lightest known substance; its specific gravity is to that of air as 732 to 10,000. It burns by the action of an

inflamed taper, when in contact with the atmosphere. The proportion in which it combines is represented by unity, or 1. It is procured by the action of diluted oil of vitriol, or hydro-sulphuric acid on filings of zinc or iron. It is the substance employed for filling air-balloons.

7. *Azote* is a gaseous substance, not capable of being condensed by any known degree of cold: its specific gravity is to that of common air as 9516 to 10,000. It does not enter into combustion under common circumstances, but may be made to unite with oxygen by the agency of electrical fire. It forms nearly four-fifths of the air of the atmosphere; and may be procured by burning phosphorus in a confined portion of air. The number representing the proportion in which it combines is 26.

8. *Carbon* is considered as the pure matter of charcoal, and it may be procured by passing spirits of wine through a tube heated red. It has not yet been fused; but raises in vapour at an intense heat. Its specific gravity cannot be easily ascertained; but that of the diamond, which cannot chemically be distinguished from pure carbon, is to that of water as 3500 to 1000. Charcoal has the remarkable property of absorbing several times its volume of different elastic fluids, which are capable of being expelled from it by heat. The number representing it is 11.4.

9. *Sulphur* is the pure substance so well known by that name: its specific gravity is to that of water as 1990 to 1000. It fuses at about 220° Fahrenheit; and at between 500° and 600° takes fire, if in contact with the air, and burns with a pale blue flame. In this process it dissolves in the oxygen of the air, and produces a peculiar acid elastic fluid. The number representing it is 30.

10. *Phosphorus* is a solid of a pale red color, of specific gravity 1770. It fuses at 90°, and boils at 550°. It is luminous in the air at common temperatures, and burns with great violence at 150°, so that it must be handled with great caution. The number representing it is 222. It is procured by digesting together bone ashes and oil of vitriol, and strongly heating the fluid substance so produced with powdered charcoal.

11. *Boron* is a solid of a dark olive color, infusible at any known temperature. It is a substance very lately discovered, and procured from boracic acid. It burns with brilliant sparks, when heated in oxygen, but not in chlorine. Its specific gravity, and the number representing it, are not yet accurately known.

12. *Silicon** is procured from silica, or the earth of flints, by the action of potassium: it appears as a dark fawn-colored powder, which is inflammable, and which produces silica by combustion. It decomposes water and acids; and detonates when heated with alkaline carbonates. It is more analogous to boron in its properties and chemical habitudes than to any other substance. 32 is an approximation to the number representing silicon.

13. *Selenion*, or, as M. Berzelius, the discoverer, names it, selenium, is a substance which forms a sort of intermediate link between the inflammable solids and the metals. It is semi-transparent, of a red color, a non-conductor of electricity, of specific gravity about 4300.

14. *Platinum* is one of the noble metals, of rather a duller white than silver, and the heaviest body in nature; its specific gravity being 21,500. It is not acted upon by any acid menstrua except such as contain chlorine; it requires an intense degree of heat for its fusion.

15. The properties of gold are well known. Its specific gravity is 19,277. It bears the same relation to acid menstrua as platinum: it is one of the characteristics of both these bodies, that they are very difficultly acted upon by sulphur.

16. *Silver* is of specific gravity 10,400; it burns more readily than platinum or gold, which require the intense heat of electricity. It readily unites to sulphur. The number representing it is 205.

17. *Mercury* is the only known metal fluid at the common temperature of the atmosphere; it boils at 660°, and freezes at 39° below 0. Its specific gravity is 13,560. The number representing it is 380.

18. *Copper* is of specific gravity 8890. It burns, when strongly heated, with red flame, tinged with green. The number representing it is 120.

19. *Cobalt* is of specific gravity 7700. Its point of fusion is very high, nearly equal to that of iron. In its calcined, or oxidated state, it is employed for giving a blue color to glass.

20. *Nickel* is of a white color: its specific gravity is 8820. This metal and cobalt agree with iron, in being attractible by the magnet. The number representing nickel is 111.

21. *Iron* is of specific gravity 7700. Its other properties are well known. The number representing it is 103.

22. *Tin* is of specific gravity 7291; it is a very fusible metal, and burns when ignited in the air: the number representing the proportion in which it combines is 110.

23. *Cadmium* is a newly discovered metal, very similar to tin in its sensible properties, of specific gravity about 9000, and is very fusible and volatile.

24. *Zinc* is one of the most combustible of the common metals. Its specific gravity is about 7210. It is a brittle metal under common circumstances; but when heated may be hammered or rolled into thin leaves, and after this operation is malleable. The number representing it is 66.

25. *Lead* is of specific gravity 11,352; it fuses at a temperature rather higher than tin. The number representing it is 398.

26. *Bismuth* is a brittle metal of specific gravity 9,822. It is nearly as fusible as tin; when cooled slowly it crystallises in cubes. The number representing it is 135.

27. *Antimony* is a metal capable of being volatilised by a strong red heat. Its specific gravity is 6,800. It burns, when ignited, with a faint white light. The number representing it is 170.

28. *Arsenic* is of a blueish white color, of specific gravity 8310. It may be procured by heating the powder of common white arsenic of the shops strongly in a Florence flask with oil. The metal raises in vapor, and condenses in the neck of the flask. The number representing it is 90.

29. *Manganesum* may be procured from the mineral called manganese, by intensely igniting it

* According to the more recent experiments of Berzelius, pure silicon is of a dark nut-brown color; a non-conductor of electricity; incombustible even in oxygen gas, and infusible before the blow-pipe. It deflagrates, and even explodes, when thrown into fused hydrate of potash or soda.—J. D.

in a forge mixed with charcoal powder. It is a metal very difficult of fusion, and very combustible: its specific gravity is 6850. The number representing it is 177.

30. *Potassium* is the lightest known metal, being only of specific gravity 850. It fuses at about 150°, and rises in vapour at heat a little below redness. It is a highly combustible substance, takes fire when thrown upon water, burns with great brilliancy, and the product of its combustion dissolves in the water. The number representing it is 75. It may be made by passing fused caustic vegetable alkali, the pure kali of druggists, through iron turnings strongly ignited in a gun barrel, or by the electrization of potash by a strong Voltaic battery.

31. *Sodium* may be made in a similar manner to potassium; soda, or the mineral alkali, being substituted for the vegetable alkali. It is of specific gravity 940. It is very combustible. When thrown upon water, it swims on its surface, hisses violently, and dissolves, but does not inflame. The number representing it is 88.

32. *Lithium* is a metal procured from a newly-discovered mineral alkali, very similar to sodium in its properties.

33. *Barium* has, as yet, been procured only by electrical powers, and in very minute quantities, so that its properties have not been accurately examined. The number representing it appears to be 130.

Strontium the 34th, *Calcium* the 35th, *Magnesium* the 36th, *Aluminum* the 37th, *Zirconum* the 38th, *Glucinum* the 39th, and *Ittrium* the 40th of the undecompounded bodies, like barium, have either not been procured absolutely pure, or only in such minute quantities that their properties are little known; they are formed either by electrical powers, or by the agency of potassium, from the different earths whose names they bear, with the change of the termination in *um;* and the numbers representing them are believed to be 90 strontium, 40 calcium, 29 magnesium, 33 aluminum, 70 zirconum, 39 glucinum, 111 ittrium.

The remaining simple bodies are metals, most of which, like those just mentioned, can only be procured with very great difficulty; and the substances in general from which they are procured are very rare in nature. They are *Palladium, Rhodium, Osmium, Iridium, Columbium, Chromium, Molybdenum, Cerium, Tellurium, Tungstenum, Titanium, Uranium.* The numbers representing these last bodies have not yet been determined with sufficient accuracy to render a reference to them of any utility.

The undecompounded substances unite with each other, and the most remarkable compounds are formed by the combinations of oxygen and chlorine with inflammable bodies and metals; and these combinations usually take place with much energy, and are associated with fire.

Combustion in fact, in common cases, is the process of the solution of a body in oxygen, as happens when sulphur or charcoal is burnt; or the fixation of oxygen by the combustible body in a solid form which takes place when most metals are burnt, or when phosphorus inflames; or the production of a fluid from both bodies, as when hydrogen and oxygen unite to form water.

When considerable quantities of oxygen or of chlorine unite to metals or inflammable bodies, they often produce acids; thus sulphureous, phosphoric, and boracic acids are formed by a union of considerable quantities of oxygen with sulphur, phosphorus, and boron: and muriatic acid gas is formed by the union of chlorine and hydrogen.

When smaller quantities of oxygen or chlorine unite with inflammable bodies or metals, they form substances not acid, and more or less soluble in water; and the metallic oxides, the fixed alkalies, and the earths, all bodies connected by analogies, are produced by the union of metals with oxygen.

The composition of any compounds, the nature of which is well known, may be easily learned from the numbers representing their elements; all that is necessary is to know how many proportions enter into union. Thus *potassa*, or the pure caustic vegetable alkali, consists of one proportion of potassium and one of oxygen, and its constitution is consequently 75 potassium, 15 oxygen.

Carbonic acid is composed of two proportions of oxygen 30, and one of carbon 11·4.

Again, *lime* consists of one proportion of calcium and one of oxygen, and it is composed of 40 of calcium and 15 of oxygen. And *carbonate of lime*, or pure chalk, consists of one proportion of carbonic acid 41·4, and one of lime 55.

Water consists of two proportions of hydrogen 2, and one of oxygen 15; and when water unites to other bodies in definite proportions, the quantity is 17, or some multiple of 17, *i. e.* 34 or 51, or 68, &c.

Soda, or the mineral alkali, contains two proportions of oxygen to one of sodium.

Ammonia, or the volatile alkali, is composed of six proportions of hydrogen and one of azote.

Amongst tbe earths, *Silica*, or the earth of flints, probably consists of two proportions of oxygen to one of silicon; and *Magnesia, Strontia, Baryta or Barytes, Alumina, Zircona, Glucina*, and *Ittria*, of one proportion of metal and one of oxygen.

The *metallic oxides* in general consist of the metals united to from one to four proportions of oxygen; and there are, in some cases, many different oxides of the same metal; thus there are three oxides of lead; the yellow oxide, or massicot, contains two *proportions* of oxygen; the *red oxide*, or *minium*, three; and the *puce-coloured oxide* four proportions. Again there are two *oxides* of *copper*, the *black* and the *orange;* the black contains two proportions of oxygen, the orange one.

For pursuing such experiments on the composition of bodies as are connected with agricultural chemistry, a few only of the undecompounded substances are necessary; and amongst the compounded bodies, the common acids, the alkalies, and the earths, are the most essential substances. The elements found in vegetables, as has been stated in the introductory lecture, are very few. Oxygen, hydrogen, and carbon constitute the greatest part of their organized matter. Azote, phosphorus, sulphur, manganesum, iron, silicum, calcium, aluminum, and magnesium, likewise in different arrangements, enter into their composition, or are found in the agents to which they are exposed; and these twelve undecompounded substances are the elements, the study of which is of the most importance to the agricultural chemist.

The doctrine of definite combinations, as will be shown in the following lectures, will assist us in gaining just views respecting the composition

of plants, and the economy of the vegetable kingdom; but the same accuracy of weight and measure, the same statical results which depend upon the uniformity of the laws that govern dead matter, cannot be expected in operations where the powers of life are concerned, and where a diversity of organs and of functions exists. The classes of definite inorganic bodies, even if we include all the crystalline arrangements of the mineral kingdom, are few, compared with the forms and substances belonging to animated nature. Life gives a peculiar character to all its productions; the power of attraction and repulsion, combination and decomposition, are subservient to it; a few elements, by the diversity of their arrangement, are made to form the most different substances; and similar substances are produced from compounds which, when superficially examined, appear entirely different.

LECTURE III.

ON THE ORGANIZATION OF PLANTS. OF THE ROOTS, TRUNK, AND BRANCHES. OF THEIR STRUCTURE. OF THE EPIDERMIS. OF THE CORTICAL AND ALBURNOUS PARTS. OF LEAVES, FLOWERS, AND SEEDS. OF THE CHEMICAL CONSTITUTION OF THE ORGANS OF PLANTS, AND THE SUBSTANCES FOUND IN THEM. OF MUCILAGINOUS, SACCHARINE, EXTRACTIVE, RESINOUS, AND OILY SUBSTANCES. AND OTHER VEGETABLE COMPOUNDS; THEIR ARRANGEMENTS IN THE ORGANS OF PLANTS, THEIR COMPOSITION, CHANGES, AND USES.

Variety characterises the vegetable kingdom; yet there is an analogy between the forms and the functions of all the different classes of plants, and on this analogy the scientific principles relating to their organization depend.

Vegetables are living structures distinguished from animals by exhibiting no signs of preception, or of voluntary motion; and their organs are either organs of nourishment or of reproduction; organs for the preservation and increase of the individual, or for the multiplication of the species.

In the living vegetable system there are to be considered the exterior form, and the interior constitution.

Every plant examined as to external structure, displays at least four systems of organs—or some analogous parts. First, the *root*. Secondly, the *trunk and branches*, or *stem*. Thirdly, the *leaves;* and, fourthly, the *flowers* or *seeds*.

The *root* is that part of the vegetable which least impresses the eye; but it is absolutely necessary. It attaches the plant to the surface, is its organ of nourishment, and the apparatus by which it imbibes food from the soil. The roots of plants, in their anatomical division, are very similar to the trunk and branches. The root may indeed be said to be a continuation of the trunk terminating in minute ramifications and filaments, and not in leaves.

When the branch or the root of a tree is cut transversely, it usually exhibits three distinct bodies: the bark, the wood, and the pith: and these again are individually susceptible of a new division.

The bark, when perfectly formed, is covered by a thin cuticle or *epidermis*, which may be easily separated. It is generally composed of a number of laminæ or scales, which in old trees are usually in a loose and decaying state. The epidermis is not vascular, and it merely defends the interior parts from injury. In forest trees, and in the larger shrubs, the bodies of which are firm, and of strong texture, it is a part of little importance; but in the reeds, the grasses, canes, and the plants having hollow stalks, it is of great use, and is exceedingly strong, and in the microscope seems composed of a kind of glassy net-work, which is principally siliceous earth.

This is the case in wheat, in the oat, in different species of equisetum, and, above all, in the rattan, the epidermis of which contains a sufficient quantity of flint to give light when struck by steel; or two pieces rubbed together produce sparks. This fact first occurred to me in 1798, and it led to experiments by which I ascertained that siliceous earth existed generally in the epidermis of the hollow plants.

The siliceous epidermis serves as a support, protects the bark from the action of insects, and seems to perform a part in the economy of these feeble vegetable tribes, similar to that performed in the animal kingdom by the shell of the crustaceous insects.

Immediately beneath the epidermis is the *parenchyma*. It is a soft substance, consisting of cells filled with fluid, having almost always a greenish tint. The cells in the parenchymatous part, when examined by the microscope, appear hexagonal. This form, indeed, is that usually affected by the cellular membranes in vegetables, and it seems to be the result of the general reaction of the solid parts, similar to that which takes place in the honeycomb. This arrangement, which has usually been ascribed to the skill and artifice of the bee, seems, as Dr. Wollaston has observed, to be merely the result of the mechanical laws which influence the pressure of cylinders composed of soft materials, the nests of solitary bees being uniformly circular.*

The innermost part of the bark is constituted by the *cortical layers*, and their numbers vary with the age of the tree. On cutting the bark of a tree of several years' standing, the productions of different periods may be distinctly seen, though the layer of every particular year can seldom be accurately defined.

The cortical layers are composed of fibrous parts which appear interwoven, and which are transverse and longitudinal. The transverse are membranous and porous, and the longitudinal are generally composed of tubes.

The functions of the parenchymatous and cortical parts of the bark are of great importance. The tubes of the fibrous parts appear to be the organs that receive the sap; the sells seem destined for the elaboration of its parts, and for the exposure of them to the action of the atmosphere, and the new matter is annually produced in the spring, immediately on the inner surface of the cortical layer of the last year.

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* My brother told me, that Dr. Wollaston, on further inquiry, relinquished the idea expressed above, and adopted the common opinion regarding the manner in which the hexagonal cells are formed.—J. D.

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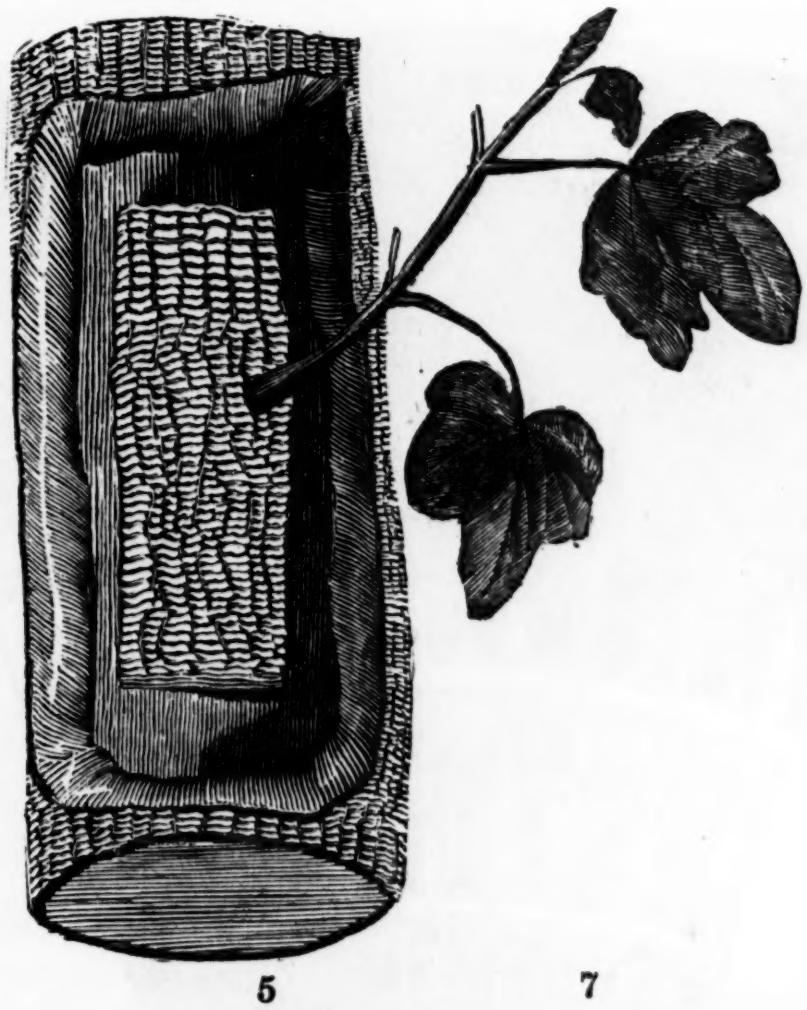

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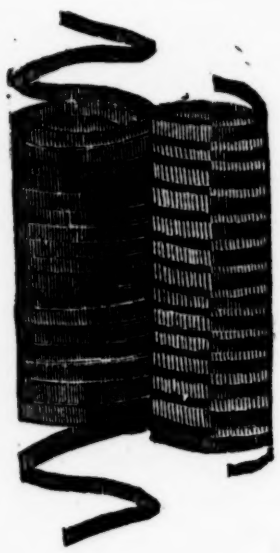

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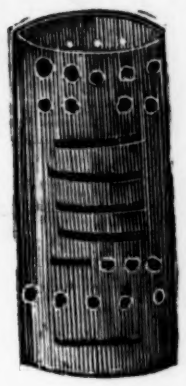

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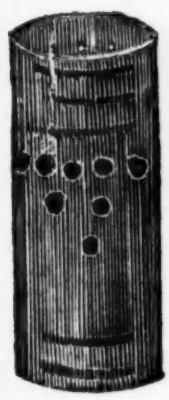

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It has been shown by the experiments of Mr. Knight, and those made by other physiologists, that the sap descending through the bark after being modified in the leaves, is the principal cause of the growth of the tree; thus, if the bark is wounded, the principal formation of new bark is on the upper edge of the wound; and when the wood has been removed, the formation of new wood takes place immediately beneath the bark: and every vessel and passage in the bark and wood of trees seems capable of carrying fluids in different and opposite directions, though more readily and copiously in one direction than in others, which offers something analogous to the anastomosis of vessels in animal bodies. A fact noticed by M. Palisot de Beauvois, is explained on this principle. That gentleman separated different portions of cortical layers from the rest of the bark in several trees, and found that in most instances the separated bark grew in the same manner as the bark in its natural state. The experiment was tried with most success on the lime-tree, the maple, and the lilac; the layers of bark were removed in August 1810, and in the spring of the next year, in the case of the maple and the lilac, small annual shoots were produced in the parts where the bark was insulated.*

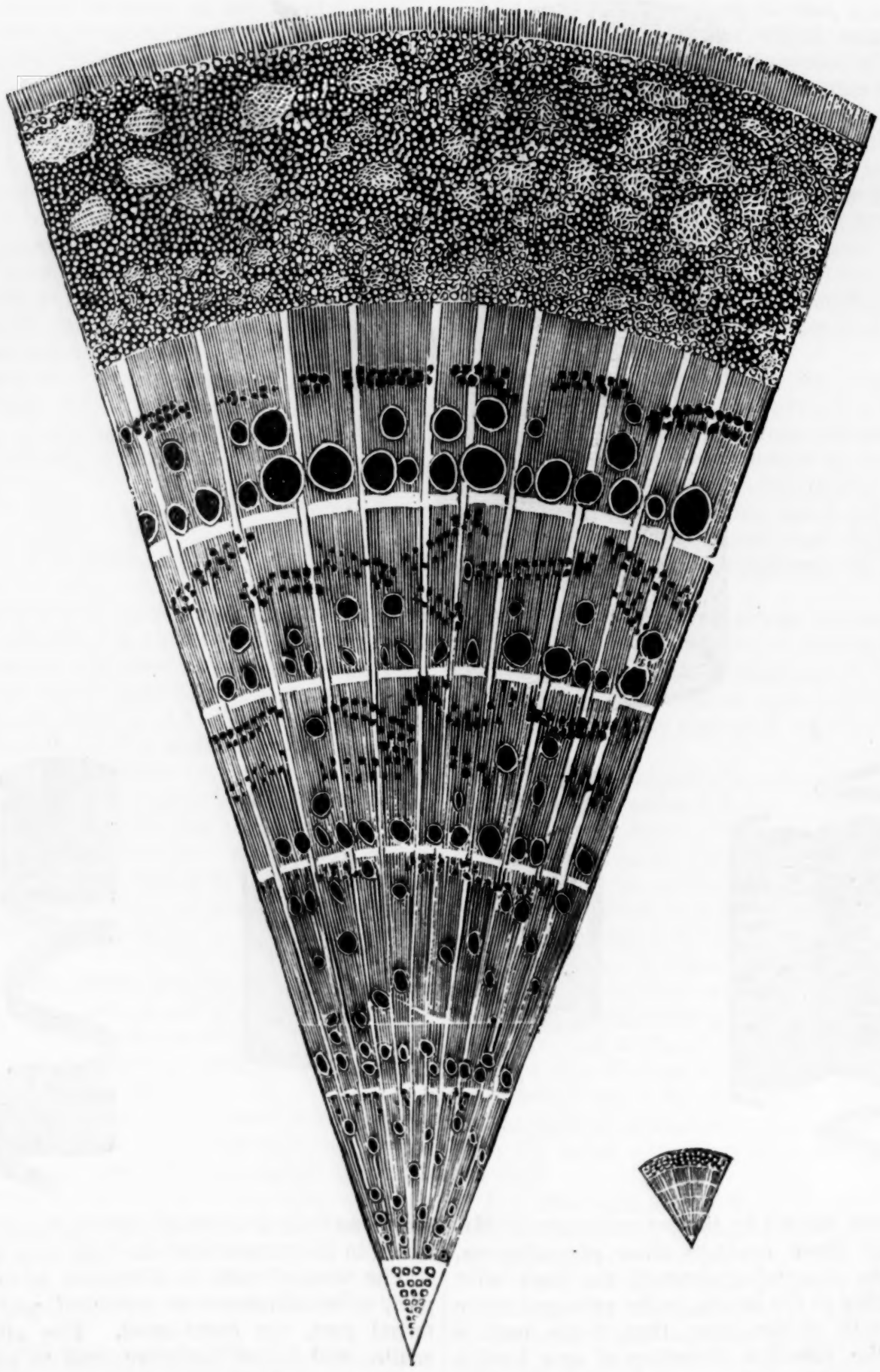
The wood of trees is composed of an external part, called *alburnum* or *sap-wood*, and of an internal part, the *heart-wood*. The alburnum is white, and full of moisture, and in young trees and annual shoots it reaches even to the pith. The alburnum is the great vascular system of the vegetable through which the sap rises, and the vessels in it extend from the leaves to the minutest filaments in the roots.

There is in the alburnum a membranous substance, composed of cells, which are constantly filled with the sap of the plant; and there are in the vascular system several different kinds of tubes; Mirbel has distinguished four species—the *simple tubes*, the *porous tubes*, the *tracheæ*, and the *false tracheæ*.†

* Fig. 3. represents the result of the experiment on the maple. Journal de Phisique, September 1811, p. 210.

† Fig. 4, 5, 6, and 7. represent Mirbel's idea of the simple tubes, the porous tubes, the tracheæ, and the false tracheæ.

Fig. 8, 9, 10.



The tubes, which he has called simple tubes, seem to contain the resinous or oily fluids peculiar to different plants.

The porous tubes likewise contain these fluids; and their use is probably that of conveying them into the sap for the production of new arrangements.

The tracheæ contain fluid matter, which is always thin, watery, and pellucid; and these organs, as well as the false tracheæ, probably carry off water from the denser juices, which are thus enabled to consolidate for the production of new wood.

In the arrangement of the fibres of the wood, there are two distinct appearances. There are series of white and shining laminæ, which shoot from the centre towards the circumference, and these constitute what is called the *silver grain* of the wood.

There are likewise numerous series of concentric layers, which are usually called the *spurious grain*, and their number denotes the age of the tree.*

The silver grain is elastic and contractile; and it has been supposed by Mr. Knight, that the contractions produced in it by changes of temperature are the principal causes of the ascent of the sap.

The silver grain is most distinct in forest trees; but even annual shrubs have a system of fibres

* Fig. 8. represents the section of an elm branch, which exhibits the tubular structure and the silver and spurious grain.

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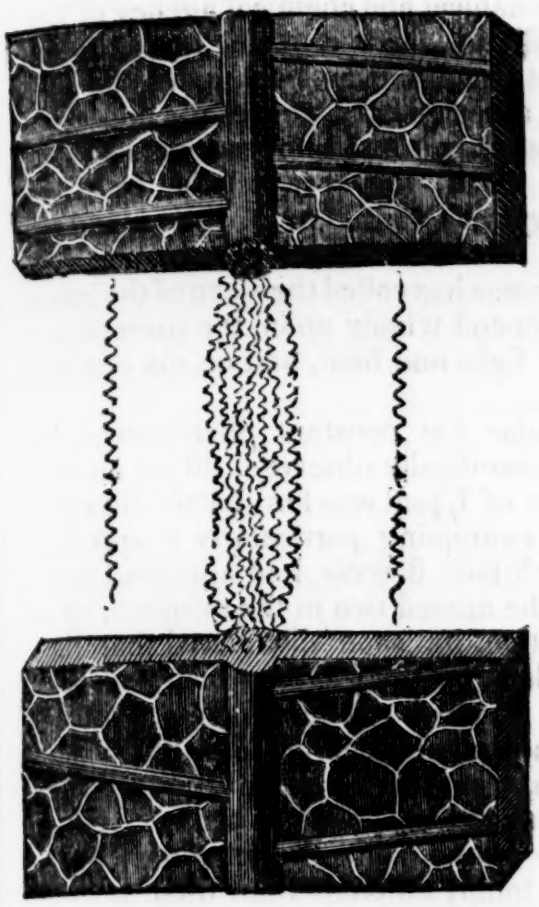

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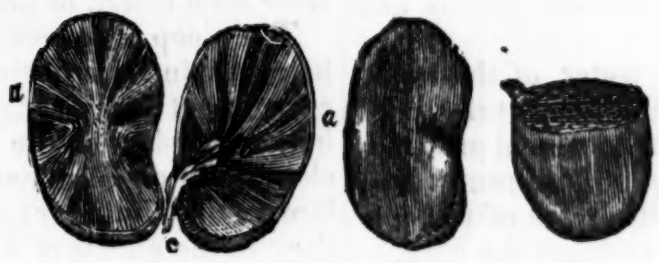

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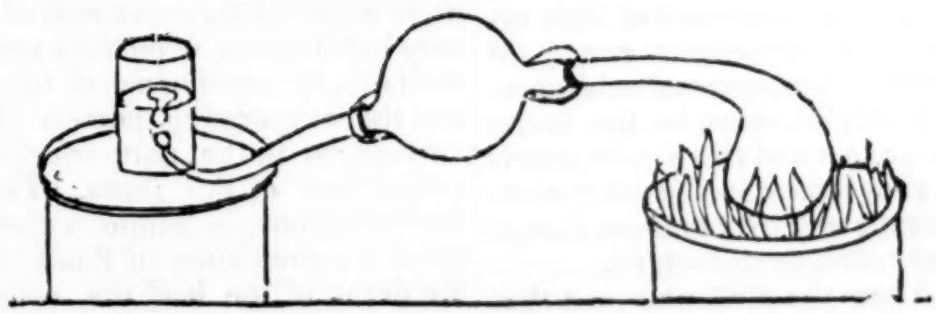

similar to it. The analogy of nature is constant and uniform, and similar effects are usually produced by similar organs.

The *pith* occupies the centre of the wood; its texture is membranous; it is composed of cells, which are circular towards the extremity, and hexagonal in the centre of the substance. In the first infancy of the vegetable, the pith occupies but a small space. It gradually dilates, and in annual shoots and young trees offers a considerable diameter. In the more advanced age of the tree, acted on by the heart-wood, pressed by the new layers of the alburnum, it begins to diminish, and in very old forest trees becomes almost imperceptible.

Many different opinions have prevailed with regard to the use of the pith. Dr. Hales supposed that it was the great cause of the expansion and developement of the other parts of the plant; that being the most interior, it was likewise the most acted upon of all the organs, and that from its reaction the phenomena of their developement and growth resulted.

Linnæus, whose lively imagination was continually employed in endeavors to discover analogies between the animal and vegetable systems, conceived "that the pith performed for the plant the same functions as the brain and nerves in animated beings." He considered it as the organ of irritability, and the seat of life.

The latest discoveries have proved that these two opinions are equally erroneous. Mr. Knight has removed the pith in several young trees, and they continued to live and to increase.

It is evidently, then, only an organ of secondary importance. In early shoots, in vigorous growth, it is filled with moisture; and it is a reservoir, perhaps, of fluid nourishment at the time it is most wanted. As the heart-wood forms, it is more and more separated from the living part, the alburnum; its functions become extinct, it diminishes, dies, and at last disappears.

The *tendrils*, the *spines*, and other similar parts of plants, are analogous in their organization to the branches, and offer a similar cortical and alburnous organization. It has been shown, by the

late observations of Mr. Knight, that the directions of tendrils, and the spiral form they assume, depend upon the unequal action of light upon them, and a similar reason has been assigned by M. De Candolle to account for the turning of the parts of plants towards the sun; that ingenious physiologist supposes that the fibres are shortened by the chemical agency of the solar rays upon them, and that, consequently, the parts will move towards the light.*

The *leaves*, the great sources of the permanent beauty of vegetation, though infinitely diversified in their forms, are in all cases similar in interior organization, and perform the same functions.

The alburnum spreads itself from the foot-stalks into the very extremity of the leaf; it retains its vascular system and its living powers; and its peculiar tubes, particularly the tracheæ, may be distinctly seen in the leaf.†

The green membranous substance may be considered as an extension of the parenchyma, and the fine and thin covering as the epidermis. Thus the organization of the roots and branches may be traced into the leaves, which present, however, a more perfect, refined, and minute structure.

One great use of the leaves is for the exposure of the sap to the influence of the air, heat and light. Their surface is extensive, the tubes and cells very delicate, and their texture porous and transparent.

In the leaves much of the water of the sap is evaporated; it is combined with new principles, and fitted for its organizing functions, and probably passes, in its prepared state, from the extreme tubes of the alburnum into the ramifications of the cortical tubes, and then descends through the bark.

On the upper surface of leaves, which is exposed to the sun, the epidermis is thick but transparent, and is composed of matter possessed of little organization, which is either principally earthy, or consists of some homogeneous chemical substance. In the grasses it is partly siliceous, in the laurel resinous, and in the maple and thorn it is principally constituted by a substance analogous to wax.

By these arrangements any evaporation, except from the appropriated tubes, is prevented.

On the lower surface the epidermis is a thin transparent membrane full of cavities, and it is probably altogether by this surface that moisture and the principles of the atmosphere necessary to vegetation are absorbed.

If a leaf be turned, so as to present its lower surface to the sun, its fibres will twist so as to bring it as much as possible into its original position; and all leaves elevate themselves on the foot-stalk during their exposure to the solar light, and as it were move towards the sun.

This effect seems, in a great measure, dependent upon the mechanical and chemical agency of light and heat. Bonnet made artificial leaves, which, when a moist sponge was held under the lower surface, and a heated iron above the upper surface, turned exactly in the same manner as the natural leaves. This, however, can be considered only as a very rude imitation of the natural process.

What Linnæus has called the sleep of the leaves, appears to depend wholly upon the suspension of the action of light and heat, and on the operation of moisture.

This singular but constant phenomenon had never been scientifically observed, till the attention of the botanist of Upsal was fortunately directed to it. He was examining particularly a species of lotus, in which four flowers had appeared during the day, and he missed two in the evening; by accurate inspection, he soon discovered that these two were hidden by the leaves, which had closed round them. Such a circumstance could not be lost upon so acute an observer. He immediately took a lantern, went into his garden, and witnessed a series of curious facts before unknown. All the simple leaves of the plants he examined had an arrangement totally different from their arrangement in the day: and the greater number of them were seen closed or folded together.

The sleep of leaves is, in some cases, capable of being produced artificially. De Candolle made this experiment on the sensitive plant. By confining it in a dark place in the day-time, the leaves soon closed; but on illuminating the chamber with many lamps, they again expanded. So sensible were they to the effects of light and radiant heat.

In the greater number of plants the leaves annually decay, and are reproduced, their decay takes place either at the conclusion of the summer, as in very hot climates, when they are no longer supplied with sap, in consequence of the dryness of the soil, and the evaporating powers of heat; or in the autumn, as in the northern climates at the commencement of the frosts. The leaves preserve their functions, in common cases, no longer than there is a circulation of fluids through them. In the decay of the leaf, the color assumed seems to depend upon the nature of the chemical change; and as acids are generally developed, it is usually either reddish-brown or yellow; yet there are great varieties. Thus in the oak, it is bright brown; in the beech, orange; in the elm, yellow; in the vine, red; in the sycamore, dark-brown; in the cornel tree, purple; and in the woodbine, blue.

The cause of the preservation of the leaves of evergreens through the winter is not accurately known. From the experiments of Hales, it appears that the force of the sap is much less in plants of this species, and probably there is a certain degree of motion in it, in warm days, even in winter; their juices are less watery than those of other plants, and probably less liable to be congealed by cold, and certainly not so easy of decomposition; and their vessels are defended by stronger coatings from the action of the elements.

The production of the other parts of the plant takes place at the time the leaves are most vigorously performing their functions. If the leaves are stripped off from a tree in spring, it uniformly dies; and when many of the leaves of forest trees are injured by blasts, or long-continued dryness,

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* According to M. De Candolle, in the side of a branch most exposed to light, more carbonic acid is decomposed and more carbon is fixed in its tissue, and consequently it sooner becomes firm and solid than on the other side where least exposed to the agent in question, and therefore the latter elongates in a greater degree than the former. The curvature towards the light is the result. *Vide* Phisiologie Végétale, par M. De Candolle, p. 832. Paris, 1832.—J. D.

† Fig. 11. represents part of a leaf of a vine magnified and cut, so as to exhibit the tracheæ; it is copied, as are also the preceding figures, from Grew's Anatomy of Plants.

the trees always become stag-headed and unhealthy.

The leaves are necessary for the existence of the individual tree; the *flowers* for the continuance of the species. Of all the parts of plants they are the most refined, the most beautiful in their structure, and appear as the master-work of nature in the vegetable kingdom. The elegance of their tints, the variety of their forms, the delicacy of their organization, and the adaptation of their parts, are all calculated to awaken our curiosity, and excite our admiration.

In the flower there are to be observed, 1st, the *calyx*, or green membranous part forming the support for the colored floral leaves. This is vascular, and agrees with the common leaf in its texture and organization; it defends, supports, and nourishes the more perfect parts. 2d, The *corolla*, which consists either of a single piece, when it is called monopetalous; or of many pieces, when it is called polypetalous. It is usually very vivid in in its colors, is filled with an almost infinite variety of small tubes of the porous kind; it incloses and defends the essential parts in the interior, and supplies the juices of the sap to them. These parts are, 3d, the *stamens* and the *pistils*.

The essential part of the stamens are the summits or *anthers*, which are usually circular and of a highly vascular texture, and covered with a fine dust called the *pollen*.

The pistil is cylindrical, and surmounted by the *style;* the top of which is generally round and protuberant.*

In the pistil, when it is examined by the microscope, congeries of spherical forms may usually be perceived, which seem to be the bases of the future seeds.

It is upon the arrangement of the stamens and the pistils that the Linnæan classification is founded. The numbers of the stamens and pistils in the same flower, their arrangements, or their division in different flowers, are the circumstances which guided the Swedish philosopher, and enabled him to form a system admirably adapted to assist the memory, and render botany of easy acquisition; and which, though it does not always associate together the plants most analogous to each other in their general characters, is yet so ingeniously contrived as to denote all the analogies of their most essential parts.

The pistil is the organ which contains the rudiments of the seed; but the seed is never formed as a reproductive germ, without the influence of the pollen, or dust on the anthers.

This mysterious impression is necessary to the continued succession of the different vegetable tribes. It is a feature which extends the resemblances of the different orders of beings, and establishes, on a great scale, the beautiful analogy of nature.

The ancients had observed that different date trees bore different flowers, and that those trees producing flowers which contained pistils bore no fruit, unless in the immediate vicinity of such trees as produced flowers containing stamens. This long-established fact strongly impressed the mind of Malpighi, who ascertained several analogous facts with regard to other vegetables. Grew, however, was the first person who attempted to generalize upon them, and much just reasoning on the subject may be found in his works. Linnæus gave a scientific and distinct form to that which Grew had only generally observed, and has the glory of establishing what has been called the sexual system, upon the basis of minute observations and accurate experiments.

The *seed*, the last production of vigorous vegetation, is wonderfully diversified in form. Being of the highest importance to the resources of nature, it is defended above all other parts of the plant; by soft pulpy substances, as in the esculent fruits; by thick membranes, as in the leguminous vegetables; and by hard shells, or a thick epidermis, as in the palms and grasses.

In every seed there is to be distinguished, 1. the *organ of nourishment;* 2. the nascent plant, or the *plume;* 3. the nascent root, or the *radicle*.

In the common garden bean, the organ of nourishment is divided into two lobes called *cotyledons;* the plume is the small white point between the upper part of the lobes; and the radicle is the small curved cone at their base.*

In wheat, and in many of the grasses, the organ of nourishment is a single part, and these plants are called *monocotyledonous*. In other cases it consists of more than two parts, when the plants are called *polycotyledonous*. In the greater number of instances, it is, however, simply divided into two, and is *dicotyledonous*.

The matter of the seed, when examined in its common state, appears dead and inert: it exhibits neither the forms nor the functions of life. But let it be acted upon by moisture, heat, and air, and its organized powers are soon distinctly developed. The cotyledons expand, the membranes burst, the radicle acquires new matter, descends into the soil, and the plume rises towards the free air. By degrees the organs of nourishment of dicotyledonous plants become vascular, and are converted into seed leaves, and the perfect plant appears above the soil. Nature has provided the elements of germination on every part of the surface, water and pure air and heat are universally active, and the means for the preservation and multiplication of life are at once simple and grand.

To enter into more minute details on the vegetable physiology would be incompatible with the objects of these lectures. I have attempted only to give such general ideas on the subject as may enable the philosophical agriculturist to understand the functions of plants; those who wish to study the anatomy of vegetables, as a distinct science, will find abundant materials in the works of the authors I have quoted, and likewise in the writings of Linnæus, Desfontaines, De Candolle, De Saussure, Bonnet, and Smith.

The history of the peculiarities of structure in the different vegetable classes rather belongs to botanical than agricultural knowledge. As I mentioned in the commencement of this lecture. their organs are possessed of the most distinct analogies, and are governed by the same laws. In the grasses and palms, the cortical layers are larger in proportion than the other parts; but their uses seem to be the same as in forest trees.

In bulbous roots, the alburnous substance forms

* Fig. 12. represents the common lily; *a* the corolla, *bbb* the anthers, *c* the pistil.

* Fig. 13. represents the garden bean; *aa* the cotyledons, *b* the plume, *c* the radicle.

the largest part of the vegetable; but in all cases it seems to contain the sap, or solid materials deposited from the sap.

The slender and comparatively dry leaves of the pine and the cedar perform the same functions as the large and juicy leave of the fig-tree, or the walnut.

Even in the cryptogamia class, where no flowers are distinct, still there is every reason to believe that the production of the seed is effected in the same way as in the more perfect plants. The mosses and lichens, which belong to this family, have no distinct leaves, or roots, but they are furnished with filaments which perform the same functions; and even in the fungus and the mushroom there is a system for the absorption and aëration of the sap.

It was stated in the last lecture, that all the different parts of plants are capable of being decomposed into a few elements. Their uses as food, or for the purposes of the arts, depend upon compound arrangements of those elements which are capable of being produced either from their organized parts, or from the juices they contain; and the examination of the nature of these substances is an essential part of agricultural chemistry.

Oils are expressed from the fruits of many plants: resinous fluids exude from the wood; saccharine matters are afforded by the sap; and dying materials are furnished by leaves, or the petals of flowers: but particular processes are necessary to separate the different compound vegetable substances from each other; such as maceration, infusion, or digestion in water, or in spirits of wine: but the application and the nature of these processes will be better understood when the chemical nature of the substances is known; the consideration of them will therefore be reserved for another place in this lecture.

The compound substances found in vegetables are, 1. gum, or mucilage, and its different modifications; 2. starch; 3. sugar; 4. albumen; 5. gluten; 6. gum elastic; 7. extract; 8. tannin; 9. indigo; 10. coloring principles; 11. bitter principles; 12. wax; 13. resins; 14. camphor; 15. fixed oils; 16. volatile oils; 17. woody fibre; 18. acids; 19. alkalies, earths, metallic oxides, and saline compounds.

I shall describe generally the properties and composition of these bodies, and the manner in which they are procured.

1. *Gum* is a substance which exudes from certain trees; it appears in the form of a thick fluid, but soon hardens in the air, and becomes solid: when it is white, or yellowish white, more or less transparent, and somewhat brittle, its specific gravity varies from 1300 to 1490.

There is a great variety of gums, but the best known are gum arabic, gum senegal, gum tragacanth, and the gum of the plum or cherry tree. Gum is soluble in water, but not soluble in spirits of wine. If a solution of gum be made in water, and spirits of wine or alcohol be added to it, the gum separates in the form of white flakes. Gum can be made to inflame only with difficulty; much moisture is given off in the process, which takes place with a dark smoke and feeble blue flame, and a coal remains.

The characteristic properties of gum are its easy solubility in water, and its insolubility in alcohol. Different chemical substances have been proposed for ascertaining the presence of gum, but there is reason to believe that few of them afford accurate results; and most of them (particularly the metallic salts), which produce changes in solutions of gum, may be conceived to act rather upon some saline compounds existing in the gum, than upon the pure vegetable principle.*

Mucilage must be considered as a variety of gum; it agrees with it in its most important properties, but seems to have less attraction for water. According to Hermbstadt, when gum and mucilage are dissolved together in water, the mucilage may be separated by means of sulphuric acid. Mucilage may be procured from linseed, from the bulbs of the hyacinth, from the leaves of the marsh-mallows, from several of the lichens, and from many other vegetable substances.

From the analysis of MM. Gay Lussac and Thenard, it appears that gum arabic contains in 100 parts,

Of Carbon - - - - -	42.23
Oxygen - - - - -	50.84
Hydrogen - - - - -	6.93

With a small quantity of saline and earthy matter.

Or, of carbon - - - - -	42.23
Oxygen and hydrogen in the proportions necessary to form water	57.77

This estimation agrees very nearly with the definite proportions of 11 of carbon, 10 of oxygen, and 20 of hydrogen.

All the varieties of gum and mucilage are nutritious as food. They either partially or wholly lose their solubility in water by being exposed to a heat of 500° or 600° Fahrenheit, but their nutritive powers are not destroyed unless they are decomposed. Gum and mucilage are employed in some of the arts, particularly in calico-printing: till lately, in this country, the calico-printers used gum arabic; but many of them, at the suggestion of Lord Dundonald, now employ the mucilage from lichens.

2. *Starch* is procured from different vegetables, but particularly from wheat or from potatoes. To make starch from wheat, the grain is steeped in cold water till it becomes soft, and yields a milky juice by pressure; it is then put into sacks of linen, and pressed in a vat filled with water: as long as any milky juice exudes the pressure is continued: the fluid gradually becomes clear, and a white powder subsides, which is starch.

Starch is soluble in boiling water, but not in cold water, nor in spirits of wine.† It is a characteristic property of starch to be rendered blue by iodine.

Starch is more readily combustible than gum; when thrown upon red-hot iron, it burns with a kind of explosion, and scarcely any residuum remains. According to MM. Gay Lussac and Thenard, 100 parts of starch are composed of

* The subacetate of lead appears to be the most delicate test of gum; according to the experiments of Berzelius, the precipitate which it occasions is composed of 38.25 oxide of lead, and 61.75 gum.—J. D.

† Exposed to a temperature a little exceeding 212°, it is rendered soluble in cold water, it becomes very similar to gum; is what De Saussure has called amidine, and is best fitted for the use of the calico-printer. Boiling water has an analogous effect on starch: boiled starch, rendered gelatinous, has the properties of amidine.—J. D.

Carbon, with a small quantity of saline and earthly matter	43.55
Oxygen - - - - -	49.68
Hydrogen - - - - -	6.77
Or,	
Carbon - - - - -	43.55
Oxygen and hydrogen in the proportions necessary to form water	56.45

Supposing this estimation correct, starch may be conceived to be constituted by 15 proportions of carbon, 13 of oxygen, and 26 of hydrogen.

Starch forms a principal part of a number of esculent vegetable substances. Sowans, cassava, salop, sago, all of them owe their nutritive powers principally to the starch they contain.

Starch has been found in the following plants: Burdock, (*Arctium Lappa,*) Deadly Nightshade (*Atropa Belladona,*) Bistort (*Polygonum Bistorta,*) White Bryony (*Bryonia alba,*) Meadow Saffron (*Colchicum autumnale,*) Dropwort (*Spiræa Filipendula,*) Buttercup (*Ranunculus bulbosus,*) Figwort (*Scrophularia nodosa,*) Dwarf Elder (*Sambucus ebulus,*) Common Elder (*Sambucus Nigra,*) Foolstones (*Orchis Morio,*) Alexanders (*Imperatoria Ostruthium,*) Henbane (*Hyoscyamus niger,*) Broad-leaved Dock (*Rumex obtusifolius,*) Sharp-pointed Dock (*Rumex acutus,*) Water Dock (*Rumex aquaticus,*) Wake Robin (*Arum maculatum,*) Salep (*Orchis mascula,*) Flower de Luce or Water-flag (*Iris Pseudacorus,*) Stinking Gladwyn (*Iris fœtidissima,*) Earthnut (*Bunium Bulbocastanum.*)

3. *Sugar* in its purest state is prepared from the expressed juice of the *Saccharum officinarum*, or sugar-cane: the acid in this juice is neutralized by lime, and the sugar is crystallized by the evaporation of the aqueous parts of the juice, and slow cooling: it is rendered white by the gradual filtration of water through it. In the common process of manufacture, the whitening or refining of sugar is only effected in a great length of time; the water being gradually suffered to percolate through a stratum of clay above the sugar. As the coloring matter of sugar is soluble in a saturated solution of sugar, or syrup, it appears that refining may be much more rapidly and economically performed by the action of syrup on colored sugar.* The sensible properties of sugar are well known. Its specific gravity according to Fahrenheit is about 1.6. It is soluble in its own weight of water at 50°; it is likewise soluble in alcohol, but in smaller proportions.

Lavoisier concluded from his experiments, that sugar consists in 100 parts, of

28 carbon,
8 hydrogen,
64 oxygen.

Dr. Thompson considers 100 parts of sugar as composed of

27.5 carbon,
7.8 hydrogen,
64.7 oxygen.

According to the recent experiments of Gay Lussac and Thenard, sugar consists of 42.47 of carbon, and 57.53 of water or its elements.

Lavoisier's and Dr. Thompson's analyses agree very nearly with the proportions of

3 of carbon,
4 of oxygen,
and 8 of hydrogen.

Gay Lussac's and Thenard's estimation gives the same elements as in gum; 11 of carbon, 10 of oxygen, 20 of hydrogen.

It appears from the experiments of Proust, Achard, Goettling, and Parmentier, that there are many different species of sugar ready formed in the vegetable kingdom. The sugar of the American maple, *Acer saccharinum*, is precisely the same as that of the cane. This sugar is used by the North American farmers, who procure it by a kind of domestic manufacture. The trunk of the tree is bored early in spring, to the depth of about two inches; a wooden spout is introduced into the hole; the juice flows for about five or six weeks. A common-sized tree, that is, a tree from two to three feet in diameter, will yield about 200 pints of sap, and every 40 pints of sap afford about a pound of sugar. The sap is neutralized by lime, and deposits crystals of sugar by evaporation.

The *sugar of grapes*, has been lately employed in France as a substitute for colonial sugar. It is procured from the juice of ripe grapes by evaporation and the action of pot-ashes; it is less sweet than common sugar, and its taste is peculiar: it produces a sensation of cold while dissolving in the mouth; and, it is probable, contains a larger portion of water, or its elements.

The roots of the beet (*Beta vulgaris* and *cicla*) afford sugar, by boiling, and the evaporation of the extract: it crystallizes, and does not differ in its properties from the sugar of the cane in France.

Manna, a substance which exudes from various trees, particularly from the *Fraxinus Ornus*, a species of ash, which grows abundantly in Sicily and Calabria, may be regarded as a variety of sugar very analogous to the sugar of grapes.* A substance analogous to manna has been extracted by Fourcroy and Vauquelin from the juice of the common onion (*Allium Cepa.*)

Besides the crystallized and solid sugars, there appears to be a sugar which cannot be separated from water, and which exists only in a fluid form; it constitutes a principal part of melasses or treacle; and it is found in a variety of fruits: it is more soluble in alcohol than solid sugar.

The simplest mode of detecting sugar is that recommended by Margraaf. The vegetable is to be boiled in a small quantity of alcohol; solid sugar, if any exist, will separate during the cooling of the solution.

Sugar has been extracted from the following vegetable substances:—

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*A French gentleman lately in this country stated to the West India planters, that he was in possession of a very expeditious and economical method of purifying and refining sugar, which he was willing to communicate to them for a very great pecuniary compensation. His terms were too high to be acceded to. Conversing on the subject with Sir Joseph Banks, I mentioned to him that I thought it probable that raw sugar might be easily purified by passing syrup through it; which would dissolve the coloring matter. The same idea seems to have occurred about the same time, or before, to the late Edward Howard, Esq., who proved its efficacy experimentally, and some time before his death took out a patent for various improvements in the manufacture of sugar.

* The substance to which manna owes its sweetness has recently been considered distinct, and called mannite. It is said not to ferment when leaven is added to its solution in water; thus differing from all the varieties of sugar.—J. D.

The sap of the Birch (*Betula alba,*) of the Sycamore (*Acer Pseudoplatanus,*) of the Bamboo (*Arundo Bambos,*) of the Maize (*Zea mays,*) of the Cow Parsnip (*Heracleum Spondylium,*) of the Cocoa-nut tree (*Cocos nucifera,*) of the Walnut tree (*Juglans alba,*) of the American aloes (*Agave Americana,*) of the Dulse (*Fucus Palmatus,*) of the Common Parsnip (*Pastanica sativa,*) of St. John's bread (*Ceratonia Siliqua;*) the fruit of the common Arbutus (*Arbutus Unedo,*) and other sweet-tasted fruits; the roots of the Turnip (*Brassica Rapa,*) of the Carrot (*Daucus Carota*) of Parsley (*Apium petroselinum,*) the flower of the Euxine Rhododendron (*Rhododendron ponticum,*) and from the nectarium of most other flowers.

The nutritive properties of sugar are well known. At the time the British market was over-stocked with this article from the West India islands, proposals were made for applying it as the food of cattle; experiments had been instituted, which proved that they might be fattened by it: but difficulties connected with the duties laid on sugar prevented the plan from being tried to any extent.

4. *Albumen* is a substance which has only lately been discovered in the vegetable kingdom. It abounds in the juice of the Papaw-tree (*Carica papaya:*) when the juice is boiled, the albumen falls down in a coagulated state. It is likewise found in mushrooms, and in different species of funguses.

Albumen, in its pure form, is a thick, glairy, tasteless fluid; precisely the same as the white of the egg; it is soluble in cold water; its solution, when not too diluted, is coagulated by boiling, and the albumen separates in the form of thin flakes. Albumen is likewise coagulated by acids and by alcohol: a solution of albumen gives a precipitate when mixed with a cold solution of nutgalls. Albumen, when burnt, produces a smell of volatile alkali, and affords carbonic acid and water; it is therefore evidently principally composed of carbon, hydrogen, oxygen, and azote.

According to the experiments of Gay Lussac and Thenard, 100 parts of albumen from the white of the egg are composed of

Carbon - -	52.883
Oxygen - -	23.872
Hydrogen - -	7.540
Azote - - -	15.705

This estimation would authorize the supposition that Albumen is composed of 2 proportions of azote, 5 oxygen, 9 carbon, 32 hydrogen.

The principal part of the almond, and of the kernels of many other nuts, appears, from the experiments of Proust, to be a substance analogous to coagulated albumen.

The juice of the fruit of the Ochra (*Hibiscus esculentus,*) according to Dr. Clarke, contains a liquid albumen in such quantities, that it is employed in Dominica, as a substitute for the white of eggs in clarifying the juice of the sugar cane.

Albumen may be distinguished from other substances by its property of coagulating by the action of heat or acids, when dissolved in water. According to Dr. Bostock, when the solution contains only one grain of albumen to 1000 grains of water, it becomes cloudy by being heated.

Albumen is a substance common to the animal as well as to the vegetable kingdom, and much more abundant in the former.

5. *Gluten* may be obtained from wheaten flour by the following process: the flower is to be made into a paste, which is to be cautiously washed, by kneading it under a small stream of water, till the water has carried off from it all the starch; what remains is gluten. It is a tenacious, ductile, elastic substance. It has no taste. By exposure to air, it becomes of a brown color. It is very slightly soluble in cold water; but not soluble in alcohol. When a solution of it in water is heated, the gluten separates in the form of yellow flakes; in this respect it agrees with albumen, but differs from it in being infinitely less soluble in water. The solution of albumen does not coagulate when it contains much less than 1000 parts of albumen: but it appears that gluten requires more than 1000 parts of cold water for its solution.

Gluten, when burnt, affords similar products to albumen, and probably differs very little from it in composition. Gluten is found in a great number of plants: Proust discovered it in acorns, chestnuts, horse-chestnuts, apples, and quinces; barley, rye, peas, and beans; likewise in the leaves of rue, cabbage, cresses, hemlock, borage, saffron, in the berries of the elder, and in the grape. Gluten appears to be one of the most nutritive of the vegetable substances; and wheat seems to owe its superiority to other grain from the circumstance of its containing it in larger quantities.

6. *Gum elastic*, or *Caoutchouc*, is procured from the juice of a tree which grows in the Brazils, called Hævea. When the tree is punctured, a milky juice exudes from it, which gradually deposits a solid substance, and this is gum elastic.

Gum elastic is pliable and soft like leather, and becomes softer when heated. In its pure state, it is white; its specific gravity is 9335. It is combustible, and burns with a white flame, throwing off a dense smoke, with a very disagreeable smell. It is insoluble in water and in alcohol; it is soluble in ether, volatile oils, and in petroleum, and may be procured from ether in an unaltered state, by evaporating its solution in that liquid. Gum elastic seems to exist in a great variety of plants: amongst them are, *Jatropha elastica*, *Ficus indica*, *Artocarpus integrifolia*, and *Urceola elastica*.

Bird-lime, a substance which may be procured from the holly, is very analogous to gum elastic in its properties. Species of gum elastic may be obtained from the misletoe, from gum-mastic, opium, and from the berries of the *Smilax caduca*, in which last plant it has been lately discovered by Dr. Barton.

Gum elastic, when distilled, affords volatile alkali, water, hydrogen, and carbon, in different combinations. It therefore consists principally of azote, hydrogen, oxygen, and carbon; but the proportions in which they are combined, have not yet been ascertained. Gum elastic is an indigestible substance, not fitted for the food of animals; its uses in the arts are well known.*

7. *Extract*, or the *extractive principle*, exists in almost all plants. It may be procured in a state of tolerable purity from saffron, by merely infusing it in water, and evaporating the solution. It may likewise be obtained from catechu, or *Terra japonica*, a substance brought from India. This

* By a very careful distillation, a very volatile fluid may be obtained from it, of sp. gr. 0.64: it is a powerful solvent of caoutchouc, and of the resins used in the preparation of varnishes.—J. D.

substance consists principally of astringent matter, and extract; by the action of water upon it, the astringent matter is first dissolved, and may be separated from the extract. Extract is always more or less colored: it is soluble in alcohol and water, but not soluble in ether. It unites with alumina, when that earth is boiled in a solution of extract; and it is precipitated by the salts of alumina, and by many metallic solutions, particularly the solution of muriate of tin.

From the products of its distillation, it seems to be composed principally of hydrogen, oxygen, carbon, and a little azote.

There appears to be almost as many varieties of extract as there are species of plants. The difference of their properties probably in many cases depends upon their being combined with small quantities of other vegetable principles, or to their containing different saline, alkaline, acid, or earthy ingredients. Many dying substances seem to be of the nature of extractive principle; such as the red coloring matter of madder, and the yellow dye, procured from weld.

Extract has a strong attraction for the fibres of cotton or linen, and combines with these substances when they are boiled in a solution of it. The combination is made stronger by the intervention of mordants, which are earthy or metallic combinations that unite to the cloth, and enable the coloring matter to adhere more strongly to its fibres.

Extract, in its pure form, cannot be used as an article of food, but it is probably nutritive when united to starch, mucilage, or sugar.

8. *Tannin*, or the tanning principle, may be procured by the action of a small quantity of cold water on bruised grape-seeds, or pounded gall-nuts; and by the evaporation of the solution to dryness.* It appears as a yellow substance, possessed of a highly astringent taste. It is difficult of combustion. It is very soluble, both in water and alcohol, but insoluble in ether. When a solution of glue, or isinglass, (*gelatine*,) is mixed with an aqueous solution of tannin, the two substances, *i. e.* the animal and vegetable matters, fall down in combination, and form an insoluble precipitate.

When tannin is distilled in close vessels, the principal products are charcoal, carbonic acid, and inflammable gases, with a minute quantity of volatile alkali. Hence its elements seem the same as those of extract, but probably in different proportions. The characteristic property of tannin is its action upon solutions of isinglass or jelly; this particularly distinguishes it from extract, with which it agrees in most other chemical qualities.

There are many varieties of tannin, which probably owe the difference of their properties to combinations with other principles, especially extract, from which it is not easy to free tannin. The purest species of tannin is that obtained from the seeds of the grape; this forms a white precipitate, with solution of isinglass. The tannin from gall-nuts resembles it in its properties. That from sumach affords a yellow precipitate; that from kino a rose-colored; that from catechu a fawn-colored one. The coloring matter of Brazil-wood, which M. Chevreul considers as a peculiar principle, and which he has called *Hematine*, differs from other species of tannin, in affording a precipitate with gelatine, which is soluble in abundance of hot water. Its taste is much sweeter than that of the other varieties of tannin, and it may perhaps be regarded as a substance intermediate between tannin and extract.

Tannin is not a nutritive substance, but is of great importance in its application to the art of tanning. Skin consists almost entirely of jelly or *gelatine*, in an organized state, and is soluble by the long-continued action of boiling water. When skin is exposed to solutions containing tannin, it slowly combines with that principle; its fibrous texture and coherence are preserved; it is rendered perfectly insoluble in water, and is no longer liable to putrefaction: in short, it becomes a substance in chemical composition precisely analogous to that furnished by the solution of jelly and the solution of tannin.

In general, in this country, the bark of the oak is used for affording tannin in the manufacture of leather: but the barks of some other trees, particularly the Spanish chestnut, have lately come into use. The following table will give a general idea of the relative value of different species of barks. It is founded on the result of experiments made by myself.

Table of numbers exhibiting the quantity of Tannin afforded by 480 *lbs. of different Barks, which express nearly their relative values.*

	LB.
Average of entire Bark of middle-sized Oak, cut in spring	29
" " " of Spanish Chestnut - -	21
" " " of Leicester Willow, large size - - -	33
" " " of Elm - - -	13
" " " of Common Willow, large	11
" " " of Ash - - -	16
" " " of Beech - - -	10
" " " of Horse Chestnut -	9
" " " of Sycamore - -	11
" " " of Lombardy Poplar -	15
" " " of Birch - -	8
" " " of Hazel - -	14
" " " of Black Thorn - -	16
" " " of Coppice Oak - -	32
" " " of Oak, cut in autumn -	21
" " " of Larch, cut in autumn -	8
White interior cortical layers of Oak Bark - -	72

The quantity of the tannin principle in barks differs in different seasons; when the spring has been very cold the quantity is smallest. On an average, 4 or 5 lbs. of good oak bark are required to form 1 lb. of leather. The inner cortical layers in all barks contain the largest quantity of tannin. Barks contain the greatest proportion of tannin at the time the buds begin to open—the smallest quantity in winter.

The extractive or coloring matters found in barks, or in substances used in tanning, influence the quality of leather. Thus skin tanned with gall-nuts is much paler than skin tanned with oak bark, which contains a brown extractive matter. Leather made from catechu is of a reddish tint. It is probable that in the process of tanning, the matter of skin and the tanning principle first enter into union, and that the leather, at the moment of its formation, unites to the extractive matter.

In general, skins in being converted into leather increase in weight about one-third; * and the ope-

* In the purest form in which it has been obtained by M. Pelouze, it is colorless, has distinct acid properties, and is converted into gallic acid by an absorption of oxygen on exposure to the atmosphere. The term tannic acid has recently been applied to it.—J. D.

* This estimation must be considered as applying to *dry* skin and *dry* leather.

ration is most perfect when they are tanned slowly. When skins are introduced into very strong infusions of tannin, the exterior parts immediately combine with that principle, and defend the interior parts from the action of the solution: such leather is liable to crack and to decay by the action of water.

The precipitates obtained from infusions containing tannin by isinglass, when dried, contain at a medium rate about 40 per cent. of vegetable matter. It is easy to obtain the comparative value of different substances for the use of the tanner, by comparing the quantities of precipitate afforded by infusions of given weights mixed with solutions of glue or isinglass.

To make experiments of this kind, an ounce or 180 grains of the vegetable substance, in coarse powder, should be acted upon by half a pint of boiling water. The mixture should be frequently stirred, and suffered to stand 24 hours; the fluid should then be passed through a fine linen cloth, and mixed with an equal quantity of solution of gelatine, made by dissolving glue, jelly, or isinglass, in hot water, in the proportion of a drachm of glue or isinglass, or six table-spoonfuls of jelly, to a pint of water. The precipitate should be collected by passing the mixture of the solution and infusion through folds of blotting-paper, and the paper exposed to the air till its contents are quite dry. If pieces of paper of equal weights are used, in cases in which different vegetable substances are employed, the difference of the weights of the papers, when dried, will indicate with tolerable accuracy the quantities of tannin contained by the substances, and their relative value, for the purposes of manufacture. Four-tenths of the increase of weight, in grains, must be taken, which will be in relation to the weights in the table.

Besides the barks already mentioned, there are a number of others which contain the tanning principle. Few barks, indeed, are entirely free from it. It is likewise found in the wood and leaves of a number of trees and shrubs, and is one of the most generally diffused of the vegetable principles.

A substance very similar to tannin has been formed by Mr. Hatchett, by the action of heated diluted nitric acid on charcoal, and evaporation of the mixture to dryness. From 100 grains of charcoal Mr. Hatchett obtained 120 grains of artificial tannin, which, like natural tannin, possessed the property of rendering skin insoluble in water.

Both natural and artificial tannin form compounds with the alkalies and the alkaline earths; and these compounds are not decomposable by skin. The attempts that have been made to render oak bark more efficient as a tanning material by infusion in lime water, are consequently founded on erroneous principles. Lime forms with tannin a compound not soluble in water.

The acids unite to tannin, and produce compounds that are more or less soluble in water. It is probable that in some vegetable substances tannin exists combined with alkaline or earthy matter; and such substances will be rendered more efficacious for the use of the tanner by the action of diluted acids.

9. *Indigo* may be procured from woad (*Isatis tinctoria,*) by digesting alcohol on it, and evaporating the solution. White crystalline grains are obtained, which gradually become blue by the action of the atmosphere: these grains are the substance in question.

The indigo of commerce is principally brought from America. It is procured from the *Indigofera argentea*, or wild indigo, the *Indigofera disperma*, or Guatimala indigo, and the *Indigofera tinctoria*, or French indigo. It is prepared by fermenting the leaves of those trees in water. Indigo, in its common form, appears as a fine deep blue powder.* It is insoluble in water, and but slightly soluble in alcohol: its true solvent is sulphuric acid: 8 parts of sulphuric acid dissolve 1 part of indigo; and the solution diluted with water forms a very fine blue dye.

Indigo by its distillation affords carbonic acid gas, water, charcoal, ammonia, and some oily and acid matter: the charcoal is in very large proportion. Pure indigo, therefore, most probably consists of carbon, hydrogen, oxygen, and azote.

Indigo owes its blue color to combination with oxygen. For the uses of the dyers, it is partly deprived of oxygen, by digesting it with orpiment and lime water, when it becomes soluble in the lime water, and of a greenish color. Cloths steeped in this solution combine with the indigo; they are green when taken out of the liquor, but become blue by absorbing oxygen when exposed to air.

Indigo is one of the most valuable and most extensively used of the dying materials.

10. There are a number of coloring principles found in different vegetable productions, the properties of which are less marked than those of indigo, and the separation more difficult. The coloring matters of carthamus and madder are the most fixed amongst the red vegetable colors. A number of vegetable substances are rendered red by the action of acids, and green by that of alkalies. They all seem to be composed of different proportions of hydrogen, oxygen, and carbon; but are so liable to change, that few distinct experiments have been made upon their nature. In dying, they are usually applied to cloths prepared for receiving them by combination with certain saline or metallic preparations called mordants; and, in consequence of the triple union formed between the cloth, the mordant, and the coloring matter, the tint is modified, or changed, and rendered more permanent.

11. The *bitter principle* is very extensively diffused in the vegetable kingdom; it is found abundantly in the hop (*Humulus Lupulus*), in the common broom (*Spartium scoparium*), in the chamomile (*Anthemis nobilis*), and in *Quassia amara* and *excelsa*. It is obtained from those substances by the action of water or alcohol, and evaporation. It is usually of pale yellow color; its taste is intensely bitter. It is very soluble, both in water and alcohol; and has little or no action on alkaline, acid, saline, or metallic solution.

An artificial substance, similar to the bitter principle, has been obtained by digesting diluted nitric acid on silk, indigo, and the wood of the white willow. This substance has the property of dying cloth of a bright yellow color; it differs

* By a carefully regulated temperature, it may be sublimed without decomposition, and obtained in a pure crystalline state.—J. D.

from the natural bitter principle in its power of combining with the alkalies; in union with the fixed alkalies, it constitutes crystallized bodies, which have the property of detonating by heat or percussion.

The natural bitter principle is of great importance in the art of brewing; it checks fermentation, and preserves fermented liquors; it is likewise used in medicine.

The bitter principle, like the narcotic principle, appears to consist principally of carbon, hydrogen, and oxygen, with a little azote.

12. *Wax* is found in a number of vegetables; it is procured in abundance from the berries of the Wax Myrtle (*Myrica cerifera*):* it may be likewise obtained from the leaves of many trees: in its pure state it is white. Its specific gravity is ·9662; it melts at 155 degrees: it is dissolved by boiling alcohol; but it is not acted upon by cold alcohol: it is insoluble in water: its properties as a combustible body are well known.

The wax of the vegetable kingdom seems to be precisely of the same nature as that afforded by the bee.†

From the experiments of MM. Gay Lussac and Thenard, it appears that 100 parts of wax consist of

Carbon - -	1·784
Oxygen - -	5·544
Hydrogen - -	12·672

Or otherwise,

Carbon - -	81·784
Oxygen and hydrogen in the proportions necessary to form water - -	6·300
Hydrogen - -	11·916

Which agrees very nearly with 37 proportions of hydrogen, 21 of charcoal, 1 of oxygen.

13. *Resin* is very common in the vegetable kingdom. One of the most usual species is that afforded by the different kinds of fir. When a portion of the bark is removed from a fir-tree in spring, a matter exudes, which is called turpentine; by heating this turpentine gently, a volatile oil rises from it, and a more fixed substance remains: this substance is resin.

The resin of the fir is the substance commonly known by the name of rosin; its properties are well known. Its specific gravity is 1072. It melts readily, burns with a yellow light, throwing off much smoke. Resin is insoluble in water, either hot or cold; but very soluble in alcohol. When a solution of resin in alcohol is mixed with water, the solution becomes milky; the resin is deposited by the stronger attraction of the water for the alcohol.

Resins are obtained from many other species of trees. *Mastich* from the *Pistacia Lentiscus*, *Elemi* from the *Amyris elemifera*, *Copal* from the *Rhus copallinum*, *Sandarach* from the common juniper. Of these resins copal is the most peculiar. It is the most difficultly dissolved in alcohol; and for this purpose must be exposed to that substance in vapor; or the alcohol employed must hold camphor in solution. According to Gay Lussac and Thenard,

100 parts of common resin contain

Carbon - -	75·944
Oxygen - -	13·337
Hydrogen - -	10·719

Or of

Carbon - -	75·944
Oxygen and hydrogen in the proportions necessary to form water	15·156
Hydrogen in excess -	8·900

According to the same chemists, 100 parts of copal consist of

Carbon - -	76·811
Oxygen - -	10·606
Hydrogen - -	12·583

Or,

Carbon - -	76·11
Water or its elements	12·052
Hydrogen - -	11·137

From these results, if resin be a definite compound, it may be supposed to consist of 8 proportions of carbon, 12 of hydrogen, and one of oxygen.

Resins are used for a variety of purposes. Tar and pitch principally consist of resin, in a partially decomposed state. Tar is made by the slow combustion of the fir; and pitch by the evaporation of the more volatile parts of tar. Resins are employed as varnishes, and for these purposes are dissolved in alcohol or oils. Copal forms one of the finest. It may be made by boiling it in powder with oil of rosemary, and then adding alcohol to the solution.

14. *Camphor* is produced by distilling the wood of the camphor-tree (*Laurus Camphora*), which grows in Japan. It is a very volatile body, and may be purified by distillation. Camphor is a white, brittle, semi-transparent substance, having a peculiar odor, and a strong acrid taste. It is very slightly soluble in water; more than 100,000 parts of water are required to dissolve one part of camphor. It is very soluble in alcohol; and by adding water in small quantities at a time to the solution of camphor in alcohol, the camphor separates in a crystallized form. It is soluble in nitric acid, and is separated from it by water.

Camphor is very inflammable; it burns with a bright flame, and throws off a great quantity of carbonaceous matter. It forms, in combustion, water, carbonic acid, and a peculiar acid called *camphoric* acid. No accurate analysis has been made of camphor, but it seems to approach to the resins in its composition; and consists of carbon, hydrogen, and oxygen.

Camphor exists in other plants besides the *Laurus Camphora*. It is procured from species of the Laurus growing in Sumatra, Borneo, and other of the East Indian isles. It has been obtained from Thyme (*Thymus Serpyllum*), Marjorum (*Origanum Majorana*), ginger tree (*Amomum Zingiber*), sage (*Salvia officinalis*). Many volatile oils yield camphor by being merely exposed to the air.

An artificial substance very similar to camphor has been formed by M. Kind, by saturating oil of

* It is also procured from the berries of the cinnamon tree (Laurus Cinnamomum.) The products of this tree are remarkable: its wood is colorless, insipid, and inodorous; its bark, as is well known, contains the oil which bears its name; its leaves, an oil similar to that of cloves; its berries, wax, as above mentioned; and its roots camphor.—J. D.

† According to the recent analysis of bees' wax and of vegetable wax by Oppermann, they differ in the proportions of their elements.—J. D.

turpentine with muriatic acid gas (the gaseous substance procured from common salt by the action of sulphuric acid.) The camphor procured in well-conducted experiments amounts to half of the oil of turpentine used. It agrees with common camphor in most of its sensible properties; but differs materially in its chemical qualities and composition. It is not soluble without decomposition in nitric acid. From the experiments of Gehlen it appears to consist of the elements of oil of turpentine, carbon, hydrogen, and oxygen, united to the elements of muriatic gas, chlorine, and hydrogen.

From the analogy of artificial to natural camphor, it does not appear improbable that natural camphor may be a secondary vegetable compound, consisting of camphoric acid and volatile oil. Camphor is used medicinally, but it has no other application.*

15. *Fixed oil* is obtained by expression from seeds and fruits; the olive, the almond, linseed, and rape-seed, afford the most common vegetable fixed oils. The properties of fixed oils are well known. Their specific gravity is less than that of water; that of olive and of rape-seed oil is ·913; that of linseed and almond oil ·932; that of palm oil ·968; that of walnut and beech-mast oil ·923. Many of the fixed oils congeal at a lower temperature than that at which water freezes. They all require for their evaporation a higher temperature than that at which water boils.† The products of the combustion of oil are water and carbonic acid gas.

From the experiments of Gay Lussac and Thenard, it appears that olive oil contains, in 100 parts.

Carbon	-	-	77·213
Oxygen	-	-	9·427
Hydrogen	-	-	13·360

This estimation is a near approximation to 11 proportions of carbon, 20 hydrogen and 1 oxygen.

The following is a list of fixed oils, and of the trees that afford them.

Olive oil, from the Olive tree (*Olea Europea*), Linseed oil, from the common and perennial Flax (*Linum usitatissimum et perenne*), Nut oil, from the Hazel nut (*Corylus Avellana*), Walnut (*Juglans regia*), Hemp oil, from the Hemp (*Cannabis sativa*), Almond oil, from the sweet Almond (*Amygdalus communis*), Beech oil, from the common Beech (*Fagus sylvatica*), Rape-seed oil, from the Rapes (*Brassica Napus et campestris*), Poppy oil, from the Poppy (*Papaver somniferum*), oil of Sesamum, from the sesamum (*Sesamum orientale*), Cucumber oil, from the gourds (*Cucurbita Pepo et Melopepo*), oil of Mustard (*Sinapos nigra et arvensis*), oil of Sunflower, from the annual and perennial Sunflower (*Helianthus annuus et perennis*), Castor oil, from the Palma Christi (*Ricinus communis*), Tobacco-seed oil, from the Tobacco (*Nicotiana Tabacum et rustica*), Plum kernel oil, from the Plum tree (*Prunus domestica*), Grape-seed oil, from the Vine (*Vitis vinifera*), Butter of cacoa, from the Cacoa tree (*Theobroma Cacao*), Laurel oil, from the sweet Bay tree (*Laurus nobilis*).

The fixed oils are very nutritive substances; they are of great importance in their applications to the purposes of life. Fixed oil, in combination with soda, forms the finest kind of hard soap. The fixed oils are used extensively in the mechanical arts, and for the preparation of pigments and varnishes.

16. *Volatile oil*, likewise called *essential oil*, differs from fixed oil, in being capable of evaporation by a much lower degree of heat, in being soluble in alcohol, and in possessing a very slight degree of solubility in water.

There is a great number of volatile oils, distinguished by their smell, their taste, their specific gravity and other sensible qualities. A strong and peculiar odor may, however, be considered as the great characteristic of each species: the volatile oils inflame with more facility than the fixed oils, and afford, by their combustion, different proportions of the same substances, water, carbonic acid, and carbon.

The following specific gravities of different volatile oils, were ascertained by Dr. Lewis:

Oil of Sassafras	1094	Oil of Tansy	946
" Cinnamon	1035	" Caraway	940
" Cloves	1034	" Origanum	940
" Fennel	997	" Spike	936
" Dill	994	" Rosemary	934
" Penny Royal	978	" Juniper	911
" Cumin	975	" Oranges	888
" Mint	975	" Turpentine	792
" Nutmegs	948		

The peculiar odours of plants seem, in almost all cases, to depend upon the peculiar volatile oils they contain. All the perfumed distilled waters owe their peculiar properties to the volatile oils they hold in solution. By collecting the aromatic oils, the fragrance of flowers, so fugitive in the common course of nature, is as it were embodied and made permanent.

It cannot be doubted that the volatile oils consist of carbon, hydrogen, and oxygen; but no accurate experiments have as yet been made on the proportions in which these elements are combined.

The volatile oils have never been used as articles of food; many of them are employed in the arts, in the manufacture of pigments and varnishes; but their most extensive application is as perfumes.

17. *Woody fibre* is procured from wood, bark, leaves or flowers of trees, by exposing them to the repeated action of boiling water and boiling alcohol. It is the insoluble matter that remains, and is the basis of the solid organized parts of plants. There are as many varieties of woody fibre as there are plants and organs of plants; but they are all distinguished by their fibrous texture, and their insolubility.

Woody fibre burns with a yellow flame, and produces water and carbonic acid in burning. When it is distilled in close vessels, it yields a considerable residuum of charcoal. It is from woody fibre, indeed, that charcoal is procured for the purposes of life.

The following table contains the results of experiments made by Mr. Mushet, on the quantity of charcoal afforded by different wood:—

* From the researches of Dumas, it would appear that camphor is an oxide of camphene, itself a compound of carbon and hydrogen.—J. D.

† From the researches of Chevreul and Le Canu, it would appear that the fixed oils consist of two principles,—a fluid principle oleine, and a solid one margarine,—the proportions of which vary in different instances.—J. D.

100 parts of Lignum Vitæ	-	26·8 of charcoal
Mahogany	-	25·4
Laburnum	-	24·5
Chestnut	-	23·2
Oak -	-	22·6
American black Beech	-	21·4
Walnut -	-	20·6
Holly -	-	19·9
Beech -	-	19·9
American Maple	-	19·9
Elm -	-	19·5
Norway Pine	-	19·2
Sallow -	-	18·4
Ash -	-	17·9
Birch -	-	17·4
Scottish Fir	-	16·4

MM. Gay Lussac and Thenard have concluded, from their experiments on the wood of the oak and the beech, that 100 parts of the first contain:—

Of Carbon	-	52·53
Oxygen	-	41·78
Hydrogen	-	5·69

and 100 parts of the second—

Of Carbon	-	51·45
Oxygen	-	42·73
Hydrogen	-	5·82

Supposing woody fibre to be a definitive compound, these estimations lead to the conclusion, that it consists of 5 proportions of carbon, 3 of oxygen, and 6 of hydrogen; or 57 carbon, 45 oxygen, and 6 hydrogen.

It will be unnecessary to speak of the applications of woody fibre. The different uses of the woods, cotton, linen, the barks of trees, are sufficiently known. Woody fibre appears to be an indigestible substance. *

18. The acids found in the vegetable kingdom are numerous; the true vegetable acids which exist ready formed in the juices or organs of plants, are the *oxalic, citric, tartaric, benzoic, acetic, meconic, malic, gallic,* and *prussic* acids.

All these acids, except the acetic, malic, and prussic acids, are white crystallized bodies. The acetic, malic, and prussic acids have been obtained only in the fluid state; they are all more or less soluble in water; all have a sour taste except the gallic and prussic acids; of which the first has an astringent taste, and the latter a taste like that of bitter almonds. The meconic acid exists in opium.

The oxalic acid exists, uncombined, in the liquor which exudes from the Chich pea (*Cicer arietinum,*) and may be procured from wood Sorrel (*Oxalis Acetosella,*) common sorrel, and other species of Rumex: and from the *Geranium acidum.* Oxalic acid is easily discovered and distinguished from other acids by its property of decomposing all calcareous salts, and forming with lime a salt insoluble in water; and by its crystallizing in four-sided prisms.

The citric acid is the peculiar acid existing in the juice of lemons and oranges. It may likewise be obtained from the cranberry, whortleberry, and hip.

Citric acid is distinguished by its forming a salt insoluble in water with lime; but decomposable by the mineral acids.

The tartaric acid may be obtained from the juice of mulberries and grapes; and likewise from the pulp of the tamarind. It is characterized by its property of forming a difficultly soluble salt with potassa, and an insoluble salt decomposable by the mineral acids with lime.

Benzoic acid may be procured from several resinous substances by distillation; from benzoin, storax, and balsam of Tolu. It is distinguished from the other acids by its aromatic odour, and by its extreme volatility.

Malic acid may be obtained from the juice of apples, barberries, plums, elderberries, currants, strawberries, and raspberries. It forms a soluble salt with lime; and is easily distinguished by this test from the acids already named.

Acetic acid, or vinegar, may be obtained from the sap of different trees. It is distinguished from malic acid by its peculiar odor; and from the other vegetable acids by forming soluble salts with the alkalies and earths.

Gallic acid may be obtained by gently and gradually heating powdered gall-nuts, and receiving the volatile matter in a cool vessel. A number of white crystals will appear, which are distinguished by their property of rendering solutions of iron deep purple.

The vegetable prussic acid is procured by distilling laurel leaves, or the kernels of the peach, and cherry, or bitter almonds. It is characterized by its property of forming a blueish green precipitate, when a little alkali is added to it, and it is poured into solutions containing iron. It is very analogous in its properties to the prussic acid obtained from animal substances; or by passing ammonia over heated charcoal; but this last body forms, with the red oxide of iron, the deep bright blue substance called Prussian blue.

Some other vegetable acids have been found in the products of plants; the morolyxic acid in a saline exudation from the white mulberry tree, and the kinic acid in a salt afforded by Peruvian bark; but these two bodies have as yet been discovered in no other cases. The igasuric acid is so named by its discoverers, MM. Pelletier and Caventou: and the boletic, nanceic, fungic, and ellagic acids, have been described by M. Braconnot; but their properties are too little interesting to the agriculturist to insert a description in this place. The phosphoric acid is found free in the onion; and the phosphoric, sulphuric, muriatic, and nitric acids, exist in many saline compounds in the vegetable kingdom; but they cannot with propriety be considered as vegetable products. Other acids are produced during the combustion of vegetable compounds, or by the action of nitric acid upon them; they are the camphoric acid, the mucous or saclactic acid, and the suberic acid; the first of which is procured from camphor; the second from gum or mucilage; and the third from cork, by the action of nitric acid.

From the experiments that have been made upon the vegetable acids, it appears that all of them, except the prussic acid, are constituted by different proportions of carbon, hydrogen, and oxygen: the prussic acid consists of carbon, azote, and hydrogen, with a little oxygen. The gallic acid contains more carbon than any of the other vegetable acids.

* By trituration and fermentation, and the heat of the oven, woody fibre may be converted into a kind of bread; by the action of strong sulphuric acid on it, it may be changed into a kind of gum, and this gum, by boiling, may be transformed into sugar: and as it is possible that similar changes may be effected in it in the alimentary canal of animals, it may not be entirely indigestible.—J. D.

The following estimates of the composition of some of the vegetable acids have been made by Gay Lussac and Thenard:—

100 parts of oxalic acid contain:		
Carbon	- -	26·566
Hydrogen	- -	2·745
Oxygen	- -	70·689
100 parts of tartaric acid contain:		
Carbon	- -	24·050
Hydrogen	- -	6·629
Oxygen	- -	69·321
Ditto citric acid:		
Carbon	- -	33·811
Hydrogen	- -	6·330
Oxygen	- -	59·859
100 parts of acetic acid:		
Carbon	- -	50·224
Hydrogen	- -	5·629
Oxygen	- -	44·147
Ditto mucous or saclactic acid:		
Carbon	- -	33·69
Hydrogen	- -	3·62
Oxygen	- -	62·69

These estimations agree nearly with the following definite proportions. In oxalic acid, 7 proportions of carbon, 8 of hydrogen, and 15 oxygen; in tartaric acid, 8 carbon, 28 hydrogen, 18 oxygen; in citric acid, 3 carbon, 6 hydrogen, 4 oxygen; in acetic acid, 18 carbon, 22 hydrogen, 12 oxygen; in mucous acid, 6 carbon, 7 hydrogen, 8 oxygen.

The applications of the vegetable acids are well known. The acetic and citric acids are extensively used. The agreeable taste and wholesomeness of various vegetable substances used as food, materially depend upon the vegetable acid they contain.

19. It is uncertain whether ammonia or the volatile alkali exists ready formed in plants: but it is evolved from many of them by the action of lime or fixed alkali, assisted by a gentle heat; though it may be always imagined to be generated during the process by the combination of azote and carbon. The ingenious researches of M. Serturner, followed by those of other chemists, have made us acquainted with the alkaline properties of several compound vegetable substances, which were not suspected to belong to this class of bodies, such as morphina, strychnina, brucina, picrotoxina, delphina*; these compounds, which are found respectively in opium, nux vomica, Brucea anti-dysenterica, cocculus indicus, and Delphinium Staphisagria, agree with alkalies in their effects upon vegetable colors, and in combining with acids, into peculiar neutrosaline compounds. They form the narcotic or poisonous principles of the plants in which they are found, and probably many more of them will be discovered. They are not very interesting to the agriculturist, except in this point of view, *that possibly many noxious vegetable substances may be rendered useful as the food of cattle*, by extracting their noxious principles by means of acids; and this is a subject well worthy of experimental investigation.

Fixed alkali may be obtained in aqueous solution from most plants by burning them, and treating the ashes with quick-lime and water. The vegetable alkali, or potassa, is the common alkali in the vegetable kingdom. This substance, in its pure state, is white and semi-transparent, requiring a strong heat for its fusion, and possessed of a highly caustic taste. In the matter usually called pure potassa by chemists, it exists, combined with water: and in that commonly called pearl-ashes, or pot-ashes in commerce, it is combined with a small quantity of carbonic acid. Potassa in its uncombined state, as has been mentioned, consists of the highly inflammable metal potassium and oxygen, one proportion of each.

Soda, or the mineral alkali, is found in some plants that grow near the sea; and is obtained combined with water, or carbonic acid in the same manner as potassa; and consists, as has been stated, of one proportion of sodium, and two proportions of oxygen. In its properties it is very similar to potassa; but it may be easily distinguished from it by this character; it forms a hard soap with oil: potassa forms a soft soap.

Pearl ashes, and barilla and kelp, or the impure soda obtained from the ashes of marine plants, are very valuable in commerce, principally on account of their uses in the manufacture of glass and soap. Glass is made from fixed alkali, flint, and certain metallic substances.

To know whether a vegetable yields alkali, it should be burnt, and the ashes washed with a small quantity of water. If the water, after being for some time exposed to the air, reddens paper tinged with turmeric, or renders vegetable blues green, it contains alkali.

To ascertain the relative quantities of pot-ashes afforded by different plants, equal weights of them should be burnt: the ashes washed in twice their volume of water: the washings should be passed through blotting paper, and evaporated to dryness. The relative weights of the salt obtained will indicate very nearly the relative quantities of alkali they contain.

The value of marine plants in producing soda may be estimated in the same manner, with sufficient correctness for all commercial purposes.

Herbs, in general, furnish four or five times, and shrubs two or three times, as much pot-ashes as trees. The leaves produce more than the branches, and the branches more than the trunk. Vegetables burnt in a green state produce more ashes than in a dry state.

The following table* contains a statement of the quantity of pot-ashes afforded by some common trees and plants:—

10,000 parts of	Oak	- -	15
	Elm	- -	39
	Beech	- -	12
	Vine	- -	55
	Poplar	- -	7
	Thistle	- -	53
	Fern	- -	62
	Cow Thistle	-	196
	Wormwood	-	730
	Vetches	- -	275
	Beans	- -	200
	Fumitory	- -	760

The earths found in plants are four; silica or the earth of flints, alumina or pure clay, lime, and mag-

* Many more have since been discovered, as codeia, narceia, aricina, &c. All the compounds of this class are composed of carbon, hydrogen, azote, and oxygen. —J. D.

* It is founded upon the experiments of Kirwan, Vauquelin, and Pertuis.

nesia. They are procured by incineration. The lime is usually combined with carbonic acid. This substance and silica, are much more common in the vegetable kingdom than magnesia, and magnesia more common than alumina. The earths form a principal part of the matter insoluble in water, afforded by the ashes of plants. The silica is known by not being dissolved by acids; the calcareous earth, unless the ashes have been very intensely ignited, dissolves with effervescence in muriatic acid. Magnesia forms a soluble and crystallizable salt, and lime a difficultly soluble one with sulphuric acid. Alumina is distinguished from the other earths by being acted upon very slowly by acids; and in forming salts very soluble in water, and difficult of crystallization with them.

The earths appear to be compounds of the peculiar metals before mentioned, and oxygen, one proportion of each.

The earths afforded by plants, are applied to no uses of common life; and there are few cases in which the knowledge of their nature can be of importance, or afford interest to the farmer.

The only *metallic oxides* found in plants, are those of iron and manganesum: they are detected in the ashes of plants; but in very minute quantities only. When the ashes of plants are reddish brown, they abound in oxides of iron. When black or purple, in oxide of manganesum; when these colours are mixed, they contain both substances.

The saline compounds contained in plants, or afforded by their incineration, are very various. The sulphuric acid combined with potassa, or sulphate of potassa, is one of the most usual. Common salt is likewise very often found in the ashes of plants; likewise phosphate of lime, which is insoluble in water, but soluble in muriatic acid. Compounds of the nitric, muriatic, sulphuric, and phosphoric acids, with alkalies and earths, exist in the sap of many plants, or are afforded by their evaporation and incineration. The salts of potassa are distinguished from those of soda by their producing a precipitate in solutions of platina: those of lime are characterized by the cloudiness they occasion in solutions containing oxalic acid; those of magnesia, by being rendered cloudy by solutions of ammonia. Sulphuric acid is detected in salts by the dense white precipitate it forms in solutions of baryta. Muriatic acid by the cloudiness it communicates to solution of nitrate of silver; and when salts contain nitric acid, they produce scintillations by being thrown upon burning coals.

As no applications have been made of any of the neutral salts or analogous compounds found in plants, in a separate state, it will be useless to describe them individually. The following tables are given from M. Th. de Saussure's Researches on vegetation, and contain results obtained by that philosopher. They exhibit the quantities of soluble salts, metallic oxides, and earths afforded by the ashes of different plants.

Besides the principles, the nature of which has been just discussed, others have been described by chemists as belonging to the vegetable kingdom: thus a substance, somewhat analogous to the muscular fibre of animals, has been detected by Vauquelin in the papaw; and a matter similar to animal gelatine, by Braconnot, in the mushroom; ulmin * and emetine, sarcocol, nicotine, olivile, asparagine, inulin, and other bodies, are generally described in systematic writers on chemistry as specific compounds; but it is likely that few of these bodies will retain their places as definite combinations: their existence, likewise, is extremely limited, and in this place it would be improper to dwell upon peculiarities; my object being to offer such general views of the constitution of vegetables as may be of use to the agriculturist. It is probable, from the taste of sarcocol, that it is gum combined with a little sugar. Inulin is so analogous to starch, that it may be a variety of that principle. If slight differences in chemical and physical properties be considered as sufficient to establish a difference in the species of vegetable substances, the catalogue of them might be enlarged to almost any extent. No two compounds procured from different vegetables are precisely alike; and there are even differences in the qualities of the same compound, according to the time in which it has been collected, and the manner in which it has been prepared. The great use of classification in science is to assist the memory, and it ought to be founded upon the similarity of properties which are distinct, characteristic, and invariable.

The analysis of any substance, containing mixtures of the different vegetable principles, may be made, in such a manner as is necessary for the views of the agriculturist, with facility. A given quantity, say 200 grains, of the substance should be powdered, made into a paste or mass, with a small quantity of water, and kneaded in the hands, or rubbed in a mortar for some time under cold water: if it contain much gluten, that principle will separate in a coherent mass. After this process, whether it has afforded gluten or not, it should be kept in contact with half a pint of cold water for three or four hours, being occasionally rubbed or agitated; the solid matter should be separated from the fluid by means of blotting paper. The fluid should be gradually heated; if any flakes appear, they are to be separated by the same means as the solid matter in the last process, *i. e.* by filtration. The fluid is then to be evaporated to dryness. The matter obtained is to be examined by applying moist paper, tinged with red cabbage juice, or violet juice, to it; if the paper become red, it contains acid matter; if it become green, alkaline matter; and the nature of the acid or alkaline matter may be known by applying the tests already described. If the solid matter be sweet to the taste, it must be supposed to contain sugar; if bitterish, bitter principle, or extract; if astringent, tannin: and if it be nearly insipid, it must be principally gum or mucilage. To separate gum or mucilage from the other principles, alcohol must be boiled upon the solid matter, which will dissolve the sugar and the extract, and leave the mucilage; the weight of which may be ascertained.

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* Ulmin, in relation to agricultural chemistry, would appear, from the researches of M. Boullay, to be a substance of some importance. It is of a dark colour, almost black; nearly insoluble in water, having some of the properties of an acid; readily combining with alkalies and the alkaline earths, with which it forms soluble compounds. It is an ingredient of peat and vegetable mould, and may be considered as a natural manure.—J. D.

	Names of Plants.	Constituents of 100 parts of Ashes.								
		Ashes from 1000 parts of the Plants green.	Ditto, dry.	Water from 1000 parts of the Plants green.	Soluble Salts.	Earthy Phosphates.	Earthy Carbonates.	Silica.	Metallic Oxides.	Loss.
1	Leaves of oak *(Quercus Robur,)* May 10	13	53	745	47	24	0·12	3	0·64	25·24
2	Ditto, September 27	24	55	549	17	28·25	23	14·5	1·75	25·5
3	Wood of young oak, May 10		4		26	28·5	12·25	0·12	1	32·58
4	Bark of ditto		60		7	4·5	63·25	0·25	1·75	22·75
5	Entire wood of oak		2		38·6	4·5	32	2	2·25	20 65
6	Alburnum of ditto				32	24	11	7·5	2	23·5
7	Bark of ditto		60		7	3	66	1·5	2	21·5
8	Cortical layers of ditto		73		7	3·75	65	0·5	1	22·75
9	Extract of wood of ditto		61		51	10·5	10	32	14	8·5
10	Soll of wood of ditto		41		24					
11	Extract from ditto		111		66					
12	Leaves of the poplar *(Populus nigra)*, May 26	23	66	652	36	13	29	5	1·25	15·75
13	Ditto, September 12	41	93	565	26	7	36	11·5	1·5	18
14	Wood of ditto, September 12		8	26	6	16·75	27	3·3	1·5	24·5
15	Bark of ditto		72			5·3	60	4	1·5	23·2
16	Leaves of hazel *(Corylus Aveliana)*, May 1		61		26	23·3	22	2·5	1·5	24·5
17	Ditto, washed in cold water		57		8·2	19·5	44·1	4	2	22 2
18	Leaves of ditto, June 22	28	62	655	22 7	14	29	11·3	1·5	21.7
19	Ditto, September 20	31	70	557	11	12	36	22	2	17
20	Wood of ditto, May 1		5		24·5	35	8	0·25	0·12	32·2
21	Bark of ditto		62		12·5	5·5	54	0·25	1·75	26
22	Entire wood of mulberry *(Morus nigra)*. November		7		21	2·25	56	0·12	0·25	20·38
23	Alburnum of ditto		13		26	27·25	24	1	0·25	21·5
24	Bark of ditto		89		7	8·5	45	15·25	1·12	23·13
25	Cortical layers of ditto		88		10	16·5	48	0·12	1	24·38
26	Entire wood of hornbeam *(Carpinus Betulus)*, November	4	6	346	22	23	26	0·12	2·25	26 63
27	Alburnum of ditto	4	7	390	18	36	15	1	1	29
28	Bark of ditto	88	134	346	4·5	4·5	59	1·5	0·12	30·38
29	Wood of horse chestnut *(Æsculus Hippocastanum)*, May 10		35		9·5					
30	Leaves of ditto, May 10	16	72	782	50					
31	Leaves of ditto, July 23	29	84	652	24					
32	Ditto, September 27	31	86	630	13·5					
33	Flowers of ditto, May 10	9	71	873	50					
34	Fruit of ditto, October 5	12	34	647	82	12		0·5	0·25	5·25
35	Plants of peas (*Pisum sativum*), in flower		95		49·8	17·25	6	2·3	1	24·65
36	Plants of peas *(Pisum sativum)*, in flower, ripe		81		34·25	22	14	11	2·5	17.25
37	Plants of vetches *(Vicia Faba)*, before flowering, May 23	16	150	895	55·5	14·5	3·5	1·5	0·5	24·50
38	Ditto, in flower, June 23	20	122	876	55·5	13·5	4·12	1·5	0·5	24·38
39	Ditto, ripe, July 23		66		50	17·75	4	1·75	0·5	26
40	Ditto, seeds separated		115		42	5·75	36	1·75	1	12 9
41	Seeds of ditto		33		69 ·28	27·92			0·5	2·3
42	Ditto, in flower, raised in distilled water		39		60·1	30			0·5	9·4
43	*Solidago vulgaris*, before flowering, May 1		92		67·5	10·75	1·5	1·5	0·75	18 25
44	Ditto, just in flower, July 15		57			59	1·5	1·5	0·75	21
45	Ditto, seeds ripe, September 20		50		48	11	17·25	3·5	1·5	18·75
46	Plants of turnsol *(Helianthas annuus)*, a month before flowering, June 23		147		63	67	11·56	1·5	0·12	16·67
47	Ditto, in flower, July 23	13	137	877	61	6	12·5	1·5	0·12	18·78
48	Ditto, bearing ripe seeds, September 20,	23	93	753	5·15	22·5	4	3·75	0·5	17·75
49	Wheat *(Triticum sativum)*, in flower				43·25	12·75	0·25	32	0·5	12·25
50	Ditto, seeds ripe				11	15	0 25	54	1	18·75
51	Ditto, a month before flowering		79	699	60	11·5	0·25	12·5	0·25	15·5
52	Ditto, in flower, June 14	16	54		41	10·75	0·25	26	0.5	21·5
53	Ditto, seeds ripe		33		10	11·75	0·25	51	0·75	23
54	Straw of wheat		43		22·5	6·2	1	61·5	1	78
55	Seeds of ditto		13		47·16	44·5		0·5	0·25	7·6
56	Bran		52		4·16	46·5		0·5	0·25	8·6
57	Plants of maize *(Zea Mays)*, a month before flowering June 23		122		69	5·75	0·25	7·5	0·25	17·25

	Names of Plants.	Ashes from 1000 parts of the Plants green.	Constituents of 1000 parts of Ashes. Ditto dry.	Water from 1000 parts of the Plant green.	Soluble Salts.	Earthy Phosphates.	Earthy Carbonates.	Silica.	Metallic Oxides.	Loss.
58	Plants of maize, in flower July 23		81		69	6	0·25	7·5	0·25	17
59	Ditto, seeds ripe		46							
60	Stalks of ditto		84		72·45	5	1	18	0·5	3·05
61	Spikes of ditto		16							
62	Seeds of ditto		10		62	36		1	0·12	0·88
63	Chaff of barley (*Hordeum vulgare*),		42		20	7·75	12·5	57	0·5	2·25
64	Seeds of ditto		18		29	32·5		35·5	0·25	2·8
65	Ditto				22	22		21	0·12	29·88
66	Oats		31		1	24		60	0·25	14·75
67	Leaves of *Rhododendron ferrugineum*, raised on Jura, a lime-stone mountain, June 20		30		23	14	43·25	0·75	3·25	15·63
68	Leaves of *Rhododendron ferrugineum*, raised on Breven, a granitic mountain, June 27		25		21·1	16·75	16·75	2	5·77	31·52
69	Branches of ditto, June 20		8		22·5	10	39	0·5	5·4	22·48
70	Spikes of ditto, June 27		8		24	11·5	29	1	11	24·5
71	Leaves of fir (*Pinus Abies*), raised on Jura, June 20		29		16	12·27	43·5	2·5	1·6	24·13
72	Ditto, raised on Breven, June 27				15	12	29	19	5·5	19·5
73	Branches of pine, June 20		29		15					
74	Whortleberry, (*Vaccinium Myrtillus*) raised on Jura, August 29		15 26		17	18	42	0·5	3·12	19.38
75	Ditto, raised on Breven		22		24	22	22	5	9·5	17·5

To separate sugar and extract, the alcohol must be evaporated till crystals begin to fall down, which are sugar; but they will generally be coloured by some extract, and can only be purified by repeated solutions in alcohol. Extract may be separated from sugar by dissolving the solid, obtained by evaporation from alcohol, in a small quantity of water, and boiling it for a long while in contact with the air. The extract will gradually fall down in the form of an insoluble powder, and the sugar will remain in solution.

If tannin exist in the first solution made by cold water, its separation is easily effected by the process before described. The solution of isinglass must be gradually added, to prevent the existence of an excess of animal jelly in the solution, which might be mistaken for mucilage.

When the vegetable substance, the subject of experiment, will afford no more principles to cold water, it must be exposed to boiling water. This will unite to starch, if there be any, and may likewise take up more sugar, extract, and tannin, provided they be intimately combined with the other principles of the compound.

The mode of separating starch is similar to that of separating mucilage.

If after the action of hot water any thing remain, the action of boiling alcohol is then to be tried. This will dissolve resinous matter; the quantity of which may be known by evaporating the alcohol.

The last agent that may be applied is ether, which dissolves elastic gum, though the application is scarcely ever necessary; for if this principle be present, it may be easily detected by its peculiar qualities.

If any fixed oil or wax exist in the vegetable substance, it will separate during the process of boiling in water, and may be collected. Any substance not acted upon by water, alcohol, or ether, must be regarded as woody fibre.

If volatile oils exist in any vegetable substances, it is evident they may be procured, and their quantity ascertained, by distillation.

When the quantity of fixed saline, alkaline, metallic, or earthy matter in any vegetable compound is to be ascertained, the compound must be decomposed by heat, by exposing it, if a fixed substance, in a crucible, to a long continued red heat; and if a volatile substance, by passing it through an ignited porcelain tube. The nature of the matter so produced may be learned by applying the tests mentioned in Lecture IV.

The only analyses in which the agricultural chemist can often wish to occupy himself, are those of substances containing principally starch, sugar, gluten, oils, mucilage, albumen, and tannin.

The two following statements will afford an idea of the manner in which the results of experiments may be arranged.

The first is a statement of the composition of ripe peas, deduced from experiments made by Einhof; the second is of the products afforded by oak bark, deduced from experiments conducted by myself.

	Parts.
3840 parts of ripe peas afford of starch	1265
Fibrous matter analogous to starch, with the coats of the peas	840
A substance analogous to gluten	
Mucilage	249
Saccharine matter	81
Albumen	66
Volatile matter	540
Earthy phosphates	11
Loss	229

1000 parts of dry oak bark, from a small tree deprived of epidermis, contain,

Of Woody Fibre	876
Tannin	57
Extract	31
Mucilage	18
Matter rendered insoluble during evaporation, probably a mixture of albumen and extract	9
Loss, partly saline matter	29

To ascertain the primary elements of the different vegetable principles, and the proportions in which they are combined, different methods of analysis have been adopted. The most simple are their decomposition by heat, or their formation into new products by combustion.

When any vegetable principle is acted on by a strong red heat, its elements become newly arranged. Such of them as are volatile are expelled in the gaseous form; and are either condensed as fluids, or remain permanently elastic. The fixed remainder is either carbonaceous, earthy, saline, alkaline, or metallic matter.

To make correct experiments on the decomposition of vegetable substances by heat, requires a complicated apparatus, much time and labor, and all the resources of the philosophical chemist; but such results as are useful to the agriculturist may be easily obtained. The apparatus necessary, is a green glass retort, attached by cement to a receiver, connected with a tube passing under an inverted jar of known capacity, filled with water.* A given weight of the substance is to be heated to redness, in the retort over a charcoal fire; the receiver is to be kept cool, and the process continued as long as any elastic matter is generated. The condensible fluids will collect in the receiver, and the fixed residuum will be found in the retort. The fluid products of the distillation of vegetable substances are principally water, with some acetous and mucous acids, and empyreumatic oil, or tar, and in some cases ammonia. The gases are carbonic acid gas, carbonic oxide, and carburetted hydrogen; sometimes with olefiant gas, and hydrogen; and sometimes, but more rarely, with azote. Carbonic acid is the only one of those gases rapidly absorbed by water; the rest are inflammable; olefiant gas burns with a bright white light; carburetted hydrogen with a light like wax; carbonic oxide with a feeble blue flame. The properties of hydrogen and azote have been described in the last lecture. The specific gravity of carbonic acid gas, is to that of air as 20.7, to 13.7, and it consists of one proportion of carbon 11.4, and two of oxygen 30. The specific gravity of gaseous oxide of carbon, is, taking the same standard, 13.2, and it consists of one proportion of carbon, and one of oxygen.

* See Fig. 14.

The specific gravities of carburetted hydrogen and olefiant gas, are respectively 8 and 13; both contain four proportions of hydrogen; the first contains one proportion, the second two proportions of carbon.

If the weight of the carbonaceous residuum be added to the weight of the fluids condensed in the receiver, and they be subtracted from the whole weight of the substance, the remainder will be the weight of the gaseous matter.

The acetous and mucous acids, and the ammonia formed, are usually in very small quantities; and by comparing the proportions of water and charcoal with the quantity of the gases, taking into account their qualities, a general idea may be formed of the composition of the substance. The proportions of the elements in the greater number of the vegetable substances which can be used as food, have been already ascertained by philosophical chemists, and have been stated in the preceding pages; the analysis by distillation, may, however, in some cases, be useful in estimating the powers of manures, in a manner that will be explained in a future lecture.

The statements of the composition of vegetable substances, quoted from MM. Gay Lussac and Thenard, were obtained by these philosophers by exposing the substances to the action of heated chlorate of potassa; a body that consists of potassium, chlorine, and oxygen; and which afforded oxygen to the carbon and the hydrogen. Their experiments were made in a peculiar apparatus, and required great caution, and were of a very delicate nature. It will not therefore be necessary to enter upon any details of them.

It is evident from the whole tenor of the statements which have been made, that the most essential vegetable substances consist of hydrogen, carbon, and oxygen in different proportions, generally alone, but in some few cases combined with azote. The acids, alkalies, earths, metallic oxides, and saline compounds, though necessary in the vegetable economy, must be considered as of less importance, particularly in their relation to agriculture, than the other principles; and as it appears from M. de Saussure's table, and from other experiments, they differ in the same species of vegetable when it is raised on different soils.

MM. Gay Lussac and Thenard have deduced three propositions, which they have called *laws*, from their experiments on vegetable substances. *The first* is, "That a vegetable substance is always acid whenever the oxygen it contains is to the hydrogen in a greater proportion than in water."

The third, "That a vegetable substance is neither acid nor resinous, but is either saccharine or mucilaginous, or analogous to woody fibre or starch, whenever the oxygen and hydrogen in it are in the same proportions as in water."

The second, "That a vegetable substance is always resinous, or oily or spirituous, whenever it contains oxygen in a smaller proportion to the hydrogen than exists in water."

New experiments upon other vegetable substances, besides those examined by MM. Gay Lussac and Thenard, are required before these interesting conclusions can be fully admitted. Their researches establish, however, the close analogy between several vegetable compounds differing in their sensible qualities, and combined with those

of other chemists, offer simple explanations of several processes in nature and art, by which different vegetable substances are converted into each other, or changed into new compounds.

Gum and sugar, excluding the different proportions of water they may contain, afford nearly the same elements by analysis; and starch differs from them only in containing a little more carbon. The peculiar properties of gum and sugar must depend chiefly upon the different arrangement, or degree of condensation of their elements; and it would be natural to conceive, from the composition of these bodies, as well as that of starch, that all three would be easily convertible one into the other; which is actually the case.

At the time of the ripening of corn, the saccharine matter in the grain, and that carried from the sap vessels into the grain, become coagulated, probably simply by losing water, and form starch. And in the process of malting, the converse change occurs. The starch of grain is converted into sugar. As there is a little absorption of oxygen, and a formation of carbonic acid in this case, it is likely that the starch loses a little carbon, which combines with the oxygen to form carbonic acid; and probably the oxygen tends to acidify the gluten of the grain, and thus breaks down the texture of the starch; gives a new arrangement to its elements, and renders it soluble in water.

Mr. Cruikshank, by exposing syrup to a substance named phosphuret of lime, which has great tendency to decompose water, converted a part of the sugar into a matter analogous to mucilage. And M. Kirchhoff, recently, has converted starch into sugar by a very simple process, that of boiling in very diluted sulphuric acid.* The proportions are 100 parts of starch, 400 parts of water, and 1 part of the sulphuric acid by weight. This mixture is to be kept boiling for 40 hours; the loss of water by evaporation being supplied by new quantities. The acid is to be neutralized by lime; and the sugar crystallized by cooling. This experiment has been tried with success by many persons. Sir C. Tuthill, from a pound and a half of potato starch, procured a pound and a quarter of crystalline, brown sugar; which he conceives possessed properties intermediate between cane-sugar, and grape-sugar.

It is probable, from the experiments of M. Theodore de Saussure, that conversion of starch into sugar, in this experiment, is effected merely by its combination with water; for his experiments prove that the acid is not decomposed, and that no elastic matter is set free, and that the sugar weighs more than the starch from which it is formed: probably the color of the sugar, is owing to the disengagement or new combination of a little carbon, the slight excess of which, as has been just stated, constitutes the only difference (independent of the different quantities of water they may contain) perceptible by analysis between sugar and starch.

M. Bouillon la Grange. by slightly roasting starch, has rendered it soluble in cold water; and the solution evaporated afforded a substance, having the characters of mucilage. And by experiments similar to those of M. Kirchhoff, M. Braconnot has lately shown that saccharine and mucilaginous substances may be procured from various forms of woody fibre; and I have seen specimens of soft sugar made from linen rags.

Gluten and albumen differ from the other vegetable products, principally by containing azote. When gluten is kept long in water, it undergoes fermentation; ammonia (which contains its azote) is given off with acetic acid; and a fatty matter and a substance analogous to woody fibre remain.

Extract, tannin, and gallic acid, when their solutions are long exposed to air, deposite a matter similar to woody fibre; and the solid substances are rendered analogous to woody fibre, by slight roasting; and in these cases it is probable that part of their oxygen and hydrogen is separated as water.

All the other vegetable principles differ from the vegetable acids in containing more hydrogen and carbon, or less oxygen; many of them, therefore, are easily converted into vegetable acids by a mere subtraction of some proportions of hydrogen. The vegetable acids, for the most part, are convertible into each other by easy processes. The oxalic contains most oxygen; the acetic the least: and this last substance is easily formed by the distillation of other vegetable substances, or by the action of the atmosphere on such of them as are soluble in water; probably by the mere combination of oxygen with hydrogen and carbon, or in some cases by the subtraction of a portion of hydrogen.

Alcohol, or spirits of wine, has been often mentioned in the course of these lectures. This substance was not described amongst the vegetable principles, because it has never been found ready formed in the organs of plants. It is procured by a change in the principles of saccharine matter, in a process called vinous fermentation.

The expressed juice of the grape contains sugar, mucilage, gluten, and some saline matter, principally composed of tartaric acid: when this juice, or *must*, as it is commonly called, is exposed to the temperature of about 70°, the fermentation begins; it becomes thick and turbid; its temperature increases, and carbonic acid gas is disengaged in abundance. In a few days the fermentation ceases; the solid matter that rendered the juice turbid falls to the bottom, and it clears; the sweet taste of the fluid is in great measure destroyed, and it is become spirituous.

Fabroni has shown that the gluten in must is essential to fermentation; and that chemist has made saccharine matter ferment, by adding to its solution in water, common vegetable gluten and tartaric acid. Gay Lussac has demonstrated that must will not ferment when freed from air by boiling, and placed out of the contact of oxygen; but that fermentation begins as soon as it is exposed to the oxygen of air, a little of that principle being absorbed; and that it then continues independent of the presence of the atmosphere.*

* Some kinds of vinegar, especially those made from sugar, are converted into an insoluble substance resembling lignin, or the principle of the woody fibre, by exposure to the atmosphere. This I have witnessed in many instances; the new substance which is like lignin, forms on the surface of the vinegar, and leaves a dense strong crust, occasionally in appearance not unlike the buffy coat of blood.—J. D.

* Farther experiments appear to be required on this subject. I have not found the fermentation of must prevented either by immersing in it phosphorus in a close vessel, or by agitating it, in contact with a minute portion of nitrous gas.—J. D.

In the manufacture of ale and porter, the sugar formed during the germination of barley is made to ferment by dissolving it in water with a little yeast, which contains gluten in the state proper for producing fermentation, and exposing it to the requisite temperature; carbonic acid gas is given off as in the fermentation of must, and the liquor gradually becomes spirituous.

Similar phenomena occur in the fermentation of the sugar in the juice of apples and other ripe fruits. It appears that fermentation depends entirely upon a new arrangement of the elements of sugar; part of the carbon uniting to oxygen to form carbonic acid, and the remaining carbon, hydrogen, and oxygen combining as alcohol; and the use of the gluten or yeast, and the primary exposure to air, seems to be to occasion the formation of a certain quantity of carbonic acid; and this change being once produced is continued; its agency may be compared to that of a spark in producing the inflammation of gunpowder; the increase of temperature occasioned by the formation of one quantity of carbonic acid occasions the combination of the elements of another quantity.

From the experiments of M. Theodore de Saussure it appears that alcohol is composed of 100 parts of olefiant (or percarburetted hydrogen gas), and of 63.58 water, or oxygen and hydrogen in the proportions necessary to form water.

Alcohol, in its purest known form, is a highly inflammable liquid, of specific gravity 796, at the temperature of 60°; it boils at about 170° Fahrenheit. This alcohol is obtained by repeated distillation of the strongest common spirit from the salt called by chemists muriate of lime, it having been previously heated red hot.

The strongest alcohol obtained by the distillation of spirit without salts has seldom a less specific gravity than 825 at 60°; and it contains, according to Lowitz's experiments, 89 parts of the alcohol of 796, and 11 parts of water. The spirit established as *proof spirit* by act of parliament passed in 1762 ought to have the specific gravity of 916; and this contains nearly equal weights of pure alcohol and water.

The alcohol in fermented liquors is in combination with water, coloring matter, sugar, mucilage, and the vegetable acids. It has been often doubted whether it can be procured by any other process than distillation; and some persons have even supposed that it *is formed* by distillation. The experiments of Mr. Brande are conclusive against both these opinions. That gentleman has shown that the coloring and acid matter in wines may be, for the most part, separated in a solid form by the action of a solution of sugar of lead (acetate of lead,) and that the alcohol may be then obtained by abstracting the water by means of hydrate of potassa or muriate of lime, without artificial heat.

The intoxicating powers of fermented liquors depend on the alcohol that they contain; but their action on the stomach is modified by the acid, saccharine, or mucilaginous substances they hold in solution. Alcohol probably acts with most efficacy when it is most loosely combined; and its energy seems to be impaired by union with large quantities of water, or with sugar or acid, or extractive matter.

The table in the following page contains the results of Mr. Brande's experiments on the quantity of alcohol of 825 at 60°, in different fermented liquors.

The spirits distilled from different fermented liquors differ in their flavor: for peculiar odorous matter, or volatile oils, rise in most cases with the alcohol. The spirit from malt usually has an empyreumatic taste like that of the oil, formed by the distillation of vegetable substances. The best brandies seem to owe their flavor to a peculiar oily matter, formed probably by the action of the tartaric acid on alcohol; and rum derives its characteristic taste from a principle in the sugar cane. All the common spirits may, I find, be deprived of their peculiar flavour by repeatedly digesting them with a mixture of well-burnt charcoal and quicklime; they then afford pure alcohol by distillation. The cognac brandies, I find, contain vegetable prussic acid, and their flavour may be imitated by adding to a solution of alcohol in water of the same strength, a few drops of the ethereal oil of wine produced during the formation of ether,* and a similar quantity of vegetable prussic acid procured from laurel leaves or any bitter kernels.

I have mentioned *ether* in the course of this Lecture; this substance is procured from alcohol by distilling a mixture of equal parts of alcohol and sulphuric acid. It is the lightest known liquid substance, being of specific gravity 632 at 60°. It is very volatile and rises in vapor, even by the heat of the body. It is highly inflammable. In the formation of ether it is most probable, from the experiments of M. de Saussure, that the elements of water merely are separated from the alcohol by the sulphuric acid, and that ether differs from alcohol in containing a larger proportion of carbon and hydrogen. Like alcohol, it possesses intoxicating powers.

A number of the changes taking place in the vegetable principles depend upon the separation of oxygen and hydrogen as water from the compound; but there is one of very great importance, in which a new combination of the elements of water is the principal operation. This is in the manufacture of bread. When any kind of flour, which consists principally of starch, is made into a paste with water, and immediately and gradually heated to about 440°, it increases in weight, and is found entirely altered in its properties; it has lost its solubility in water, and its power of being converted into sugar. In this state it is unleavened bread.

When the flour of corn or the starch of potatoes, mixed with boiled potatoes, is made into a paste with water, kept warm, and suffered to remain 30 or 40 hours, it ferments, carbonic acid gas is disengaged from it, and it becomes filled with globules of elastic fluid. In this state it is raised dough, and affords, by baking, leavened bread; but this bread is sour and disagreeable to the taste; and leavened bread for use is made by mixing a little dough, that has fermented, with new dough, and kneading them together, or by kneading the bread with a small quantity of yeast.

In the formation of wheaten bread, more than one quarter of the elements of water combine

* In the process of the distillation of alcohol and sulphuric acid after the ether is procured; by a higher degree of heat, a yellow fluid is produced; which is the substance in question. It has a fragrant smell and an agreeable taste.

Wine.	Proportion of Alcohol, per cent. by measure.	Wine.	Proportion of Alcohol, per cent. by measure.
Port	19.00	Frontignac	12.79
Ditto	21.40	Coti Roti	12.32
Ditto	22.30	Rousillon	17.26
Ditto	33.39	Ditto	19.00
Ditto	23.71	Cape Madeira	18.11
Ditto	24.29	Ditto	20.50
Ditto	25.83	Ditto	22.94
Average	22.96	Cape Muscat	18.25
Madeira	19.24	White Constantia	19.75
Ditto (Sercial)	21.40	Red Constantia	18.92
Ditto	23.93	Tent	13.30
Ditto	24.42	Sheraaz	15.52
Average	22.27	Syracuse	15.28
Sherry	18.25	Nice	14.63
Ditto	18.79	Tokay	9.88
Ditto	19.81	Lissa	26.47
Ditto	19.83	Ditto	24.35
Average	19.17	Teneriffe	19.79
Claret	12.91	Colares	19.75
Ditto	14.08	Lachryma Christi	19.70
Ditto	16.32	Vidonia	19.25
Ditto	17.11	Alba flora	17.26
Average	15.10	Zante	17.05
Calcavella	18.10	Lunel	15.52
Ditto	19.20	Sautern	14.22
Lisbon	18.94	Barsac	13.86
Malaga	17.26	Raisin Wine	25.77
Ditto	18.94	Ditto	26.40
Bucellas	18.49	Ditto	23.20
Red Madeira	18.40	Orange Wine	11.26
Ditto	22.30	Grape Wine	18.11
Malmsey Madeira	16.40	Currant Wine	20.55
Marsala	25.05	Gooseberry Wine	11.84
Ditto	26.03	Elder Wine	8.79
Red Champagne	11.30	Mead	7.32
Ditto	12.56	Cider	9.87
White Champagne	12.80	Ditto	5.21
Still Champagne	13.80	Perry	7.26
Burgundy	14.53	Brown Stout	6.80
Ditto	11.95	Ale (Burton)	8.88
Ditto	15.22	Edinburgh	6.20
Ditto	16.80	Dorchester	5.56
White Hermitage	17.43	London Porter	4.20
Red Hermitage	12.32	Small Beer	1.28
Hock	14.37	Brandy	53.39
Ditto	13.00	Rum	53.68
Ditto	8.88	Hollands	51.60
Vin de Grave	12.80	Scotch Whiskey	54.32
Ditto	13.94	Irish Whiskey	53.90

with the flour; more water is consolidated in the formation of bread from barley, and still more in that from oats; but the gluten in wheat, being in much larger quantity than in other grain, seems to form a combination with the starch and water, which renders wheaten bread more digestible than the other species of bread.*

The arrangement of many of the vegetable principles in the different parts of plants has been incidentally mentioned in this lecture; but a more particular statement is required to afford just views of the relation between their organization and chemical constitution, which is an object of great importance. The tubes and hexagonal cells in the vascular system of plants are composed of woody fibre; and when they are not filled with fluid matter they contain some of the solid materials which formed a constituent part of the fluids belonging to them.

In the roots, trunk, and branches, the bark, alburnum, and heart-wood, the leaves and flowers, the great basis of the solid parts is woody fibre. It forms by far the greatest part of the heart-wood and bark; there is less in the alburnum, and still less in the leaves and flowers. The alburnum of the birch contains so much sugar and mucilage, that it is sometimes used in the north of Europe as a substitute for bread. The leaves of the cabbage, broccoli, and seacale, contain much mucilage, and a little saccharine matter,

*In the process of the conversion of flour into bread, it has lately been ascertained that alcohol is formed as well as carbonic acid; thus approaching the panary fermentation (as the raising of bread has been sometimes called), to the vinous. But the proportion of alcohol produced appears to be small. What the changes effected are have not yet been thoroughly investigated, especially of the gluten.—J. D

and a little albumen. From 1000 parts of the leaves of common cabbage, I obtained 41 parts of mucilage, 24 of sugar, and 8 of albuminous matter.

In bulbous roots, and sometimes in common roots, a large quantity of starch, albumen, and mucilage are often found deposited in the vessels; and they are most abundant after the sap has ceased to flow; and afford a nourishment for the early shoots made in spring. The potato is the bulb that contains the largest quantity of soluble matter in its cells and vessels; and it is of most importance in its application as food. Potatoes in general afford from one-fifth to one-seventh their weight of dry starch. From 100 parts of the common *Kidney potato*, Dr. Pearson obtained from 32 to 28 parts of meal, which contained from 23 to 20 of starch and mucilage; and 100 parts of the *Apple potato* in various experiments, afforded me from 18 to 20 parts of pure starch. From five pounds of the variety of the potato called *Captain hart*, Mr. Skrimshire, jun. obtained 12 ounces of starch, from the same quantity of the *Rough red* potato 10½ ounces, from the *Moulton white* 11¾, from the *Yorkshire kidney*, 10¾ ounces, from *Hundred eyes* 9 ounces, from *Purple red* 8½, from *Ox noble* 8¼. The other soluble substances in the potato are albumen and mucilage.

From the analysis of Einhoff it appears that 7680 parts of potato afford,

Of Starch - - -	1153
— Fibrous matter analogous to starch	540
— Albumen - - -	107
— Mucilage in the state of a saturated solution - - -	312
	2122

So that a fourth part of the weight of the potato at least may be considered as nutritive matter. Mr. Knight informs me, that he has found the best potatoes, such as the Irish apple, to possess much greater specific gravity than the inferior varieties; the specific gravity varying from 1075 to 1100, and it is probable that their nutritive properties are nearly proportionate to their specific gravities.

The turnip, carrot, and parsnip, afford principally saccharine, mucilaginous, and extractive matter. I obtained from 1000 parts of common turnips, 7 parts of mucilage, 34 of saccharine matter, and nearly 1 part of albumen. 1000 parts of carrots furnished 95 parts of sugar, 3 parts of mucilage, and ½ part of extract; 1000 parts of parsnip afforded 90 parts of saccharine matter, and 9 parts of mucilage. The *Walcheren* or *white carrot*, gave, in 1000 parts, 98 parts of sugar, 2 parts of mucilage, and 1 of extract.

Fruits, in the organization of their soft parts, approach to the nature of bulbs. They contain a certain quantity of nourishment laid up in their cells for the use of the embryon plant; mucilage, sugar, starch, are found in many of them often combined with vegetable acids. Most of the fruit trees common in Britain have been naturalized on account of the saccharine matter they contain, which, united to the vegetable acids and mucilage, renders them at once agreeable to the taste, and nutritive.

The value of fruits for the manufacture of fermented liquors, may be judged of from the specific gravity of their expressed juices; but the quantity of juice and the consistence of the pulp differ widely in different species of fruits, and therefore the specific gravity of the fruit will not always indicate the value of its fermented produce. The best cider and perry are made from those apples and pears that afford the densest juices; and a comparison between different fruits may be made with tolerable accuracy by plunging them together into a saturated solution of salt, or a strong solution of sugar; those that sink deepest will afford the richest juice.*

Starch or coagulated mucilage forms the greatest part of the seeds and grains used for food; and they are generally combined with gluten, oil, or albuminous matter. In corn, with gluten; in peas and beans, with albuminous matter; and in rape seed, hemp seed, linseed, and the kernels of most nuts, with oils.

I found 100 parts of good full-grained wheat sown in autumn, to afford

Of Starch - -	77
— Gluten - -	19
100 parts of wheat sown in spring,	
Of Starch - -	70
— Gluten - -	24
100 parts of Barbary wheat,	
Of Starch - -	74
— Gluten - -	23
100 parts of Sicilian wheat,	
Of Starch - -	75
— Gluten - -	21

I have examined different specimens of North American wheat; all of them have contained rather more gluten than the British. In general, the wheat of warm climates abounds more in gluten, and in insoluble parts; and it is of greater specific gravity, harder, and more difficult to grind.

The wheat of the south of Europe, in consequence of the larger quantity of gluten it contains, is peculiarly fitted for making macaroni, and other preparations of flour, in which a glutinous quality is considered as an excellence.

In some experiments made on barley, I obtained from 100 parts of full and fair Norfolk barley,

Of Starch - - - -	79
— Gluten - - -	6
— Husk - - -	8

The remaining 7 parts saccharine matter. The sugar in barley is probably the chief cause why it is more proper for malting than any other species of grain.

Einhoff has published a minute analysis of barley meal. He found in 3840 parts,

Of volatile matter - -	360
— Albumen - - -	44
— Saccharine matter - -	200
— Mucilage - - -	176
— Phosphate of lime, with some albumen	9
— Gluten - - -	135
— Husk, with some gluten and starch	260
— Starch not quite free from gluten	2580
— Loss - - - -	78

* The specific gravity of the expressed juice of the water melon, the most succulent of fruits, exceeds very little that of distilled water. One specimen of water melon, which I examined in Malta, yielded 97 parts of water, and 3 of solid matter, principally saccharine and mucilaginous.—J. D.

Rye afforded to Einhoff, in 3840 parts, 2520 meal, 930 husk, and 390 moisture; and the same quantity of meal analysed gave,

Of Starch - - -	2345
— Albumen - - -	116
— Mucilage - - -	426
— Saccharine matter - -	126
— Gluten not dried - -	364

Remainder husk and loss.

I obtained from 1000 parts of rye, grown in Suffolk, 61 parts of starch, and 5 parts of gluten.

100 parts of oats, from Sussex afforded me 59 parts of starch, 6 of gluten, and 2 of saccharine matter.

1000 parts of peas, grown in Norfolk, afforded me 501 parts of starch, 22 parts of saccharine matter, 35 parts of albuminous matter, and 16 parts of extract, which became insoluble during evaporation of the saccharine fluid.

From 3840 parts of marsh beans (*Vicia faba*), Einhoff obtained,

Of Starch - - -	1312
—Albumen - - - -	31
— Other matters which may be conceived nutritive; such as gummy, starchy, fibrous matter analogous to animal matter - - -	1204

The same quantity of kidney beans (*Phaseolus vulgaris*), afforded,

Of matter analogous to starch -	1805
— Albumen and matter approaching to animal matter in its nature	851
—Mucilage - - -	799

From 3840 parts of lentiles, he obtained 1260 parts of starch, and 1433 of a matter analogous to animal matter.

The matter analogous to animal matter is described by Einhoff, as a glutinous substance insoluble in water; soluble in alcohol; when dry, having the appearance of glue; probably a peculiar modification of gluten.

From 16 parts of hemp seed, Bucholz obtained 3 parts of oil, $3\frac{1}{2}$ parts of albumen, about $1\frac{3}{4}$ of saccharine and gummy matter. The insoluble husks and coats of the seed weighed $6\frac{1}{8}$ parts.

The different parts of flowers contain different substances: the pollen, or impregnating dust of the date, has been found by Fourcroy and Vauquelin to contain a matter analogous to gluten, and a soluble extract abounding in malic acid. Link found in the pollen of the hazel-tree, much tannin and gluten.

Saccharine matter is found in the nectarium of flowers, or the receptacles within the corolla, and by tempting the larger insects into the flowers, it renders the work of impregnation more secure; for the pollen is often by their means applied to the stigma; and this is particularly the case when the male and female organs are in different flowers or different plants.

It has been stated, that the fragrance of flowers depends upon the volatile oils they contain; and these oils, by their constant evaporation, surround the flower with a kind of odorous atmosphere; which at the same time that it entices larger insects, may probably preserve the parts of fructification from the ravages of smaller ones. Volatile oils, or odorous substances, seem particularly destructive to these minute insects and animalcules which feed on the substance of vegetables; thousands of aphides may be usually seen in the stalk and leaves of the rose; but none of them are ever observed on the flower. Camphor is used to preserve the collections of naturalists. The woods that contain aromatic oils are remarked for their indestructibility; and for their exemption from the attacks of insects: this is particularly the case with the cedar, rose-wood, and cypress. The gates of Constantinople, which were made of this last wood, stood entire from the time of Constantine, their founder, to that of Pope Eugene IV., a period of 1100 years.

The petals of many flowers afford saccharine and mucilaginous matter. The white lily yields mucilage abundantly; and the orange lily a mixture of mucilage and sugar; the petals of the convolvulus afford sugar, mucilage, and albuminous matter.

The chemical nature of the coloring matters of flowers has not as yet been subject to any very accurate observation. These coloring matters, in general, are very transient, particularly the blues and reds; alkalies change the colors of most flowers to green, and acids to red. An imitation of the coloring matter may be made by digesting solutions of gall-nuts with chalk: a green fluid is obtained, which becomes red by the action of an acid; and has its green color restored by means of alkalies.

The yellow coloring matters of flowers are the most permanent; the carthamus contains a red and a yellow coloring matter; the yellow coloring matter is easily dissolved by water, and from the red, rouge is prepared by a process which is kept secret.

The same substances as exist in the solid parts of plants are found in their fluids, with the exception of woody fibre. Fixed and volatile oils, containing resin or camphor, or analogous substances in solution, exist in the cylindrical tubes belonging to a number of plants. Different species of euphorbia emit a milky juice, which when exposed to air deposites a substance analogous to starch, and another similar to gluten.

Opium, gum elastic, gamboge, the poisons of the *Upas antiar* and *Tieute*, and other substances that exude from plants, may be considered as peculiar juices belonging to appropriate vessels.

The sap of plants, in general, is very compound in its nature; and contains more saccharine, mucilaginous, and albuminous matter in the alburnum; and most tannin and extract in the bark. The cambium, which is the mucilaginous fluid found in trees between the wood and the bark, and which is essential to the formation of new parts, seems to be derived from these two kinds of sap; and probably is a combination of the mucilaginous and albuminous matter of one, with the astringent matter of the other, in a state fitted to become organized by the separation of its watery parts.

The alburnous saps of some trees have been chemically examined by Vauquelin. He found in those of the elm, beech, yoke elm, hornbeam, and birch, extractive and mucilaginous matter, and acetic acid combined with potassa or lime. The solid matter afforded by their evaporation yielded an ammoniacal smell, probably owing to albumen: the sap of the birch afforded saccharine matter.

Deyeux in the sap of the vine and the yoke elm has detected a matter analogous to the curd

of milk. I found a substance similar to albumen in the sap of the walnut tree.

I found the juice which exudes from the vessels of the marshmallow when cut, to be a solution of mucilage.

The fluids contained in the sap vessels of wheat and barley, afforded in some experiments which I made on them, mucilage, sugar, and a matter which coagulated by heat; which last was most abundant in wheat.

The following table contains a statement of the quantity of soluble or nutritive matters existing in varieties of the different substances that have been mentioned, and of some others which are used as articles of food, either for man or cattle. The analyses are my own; and were conducted with a view to a knowledge of the general nature and quantity of the products, and not of their intimate chemical composition. The soluble matters afforded by the grasses, except that from the fiorin in winter, were obtained by Mr. Sinclair, gardener to the Duke of Bedford, from given weights of the grasses cut when the seeds were ripe; they were sent to me by his Grace's desire for chemical examination, and form part of the results of an important and extensive series of experiments on grasses made by direction of the Duke, at Woburn Abbey, when pursuing those plans for the improvement of agriculture, the origin of which have thrown so much glory on the memory of his illustrious brother.

Table of the Quantities of soluble or nutritive Matters afforded by 1000 *Parts of different vegetable Substances.*

Vegetables or vegetable Substance.	Whole Quantity of soluble or nutritive matter.	Mucilage or Starch.	Saccharine matter or Sugar.	Gluten or Albumen.	Extract or matter rendered insoluble during evaporation.
Middlesex wheat, average crop	955	765	—	190	
Spring wheat	940	700	—	240	
Mildewed wheat of 1806	210	178	—	32	
Blighted wheat of 1804	650	520	—	130	
Thick-skinned Sicilian wheat of 1810	955	725	—	230	
Thin-skinned Sicilian wheat of 1810	961	722	—	239	
Wheat from Poland	950	750	—	200	
North American wheat	955	730	—	225	
Norfolk barley	920	790	70	60	
Oats from Scotland	743	641	15	87	
Rye from Yorkshire	792	645	38	109	
Common bean	570	426	—	103	41
Dry peas	574	501	22	35	16
Potatoes	from 260 to 200	from 200 to 155	from 20 to 15	from 40 to 30	
Linseed cake	151	123	11	17	
Red beet	148	14	121	13	
White beet	136	13	119	4	
Parsnip	99	9	90		
Carrots	98	3	95		
Common turnips	42	7	34	1	
Swedish turnips	64	9	51	2	2
Cabbage	73	41	24	8	
Broad-leaved clover	39	31	3	2	3
Long-rooted clover	39	30	4	3	2
White clover	32	29	1	3	5
Sainfoin	39	28	2	3	6
Lucerne	23	18	1	—	4
Meadow fox-tail grass	33	24	3	—	6
Perennial rye grass	39	26	4	—	5
Fertile meadow grass	78	65	6	—	7
Roughish meadow grass	39	29	5	—	6
Crested dog's-tail grass	35	28	3	—	4
Spiked fescue grass	19	15	2	—	2
Sweet-scented soft grass	82	72	4	—	6
Sweet-scented vernal grass	50	43	4	—	3
Fiorin	54	46	5	1	2
Fiorin cut in winter	76	64	8	1	3

All these substances were submitted to experiment green, and in their natural states. It is probable that the excellence of the different articles, as food, will be found to be in a great measure proportional to the quantities of soluble or nutritive matters they afford; but still these quantities cannot be regarded as *absolutely* denoting their value. Albuminous or glutinous matters have the characters of animal substances; sugar is more nourishing, and extractive matter less nourishing, than any other principles composed of carbon, hydrogen, and oxygen. Certain combinations likewise of these substances may be more nutritive than others.

I have been informed by Sir Joseph Banks, that the Derbyshire miners, in winter, prefer oat-

cakes to wheaten bread; finding that this kind of nourishment enables them to support their strength and perform their labour better. In summer, they say oat-cake heats them, and they then consume the finest wheaten bread they can procure. Even the skin of the kernel of oats probably has a nourishing power, and is rendered partly soluble in the stomach with the starch and gluten. In most countries of Europe, except Britain, and in Arabia, horses are fed with corn of different kinds, mixed with chopped straw; and the chopped straw seems to act the same part as the husk of the oat. In the mill 14 lbs. of good wheat yield on an average 13 lbs. of flour; the same quantity of barley 12 lbs., and of oats only 8 lbs.

In the south of Europe, hard or thin-skinned wheat is in higher estimation, than soft or thick-skinned wheat; the reason of which is obvious, from the larger quantity of gluten and nutritive matter it contains. I have made an analysis of only one specimen of thin-skinned wheat, so that other specimens may possibly contain more nutritive matter than that in the table; the Barbary and Sicilian wheats. before referred to, were thick-skinned wheats. In England, the difficulty of grinding thin-skinned wheat is an objection; but this difficulty is easily overcome by moistening the corn.*

LECTURE IV.

ON SOILS: THEIR CONSTITUENT PARTS. ON THE ANALYSIS OF SOILS. OF THE USES OF THE SOIL. OF THE ROCKS AND STRATA FOUND BENEATH SOILS. OF THE IMPROVEMENT OF SOIL.

No subjects are of more importance to the farmer than the nature and improvement of soils; and no parts of the doctrines of agriculture are more capable of being illustrated by chemical inquiries.

Soils are extremely diversified in appearance and quality; yet, as it was stated in the introductory lecture, they consist of different proportions of the same elements; which are in various states of chemical combination, or mechanical mixture.

The substances which constitute soils have been already mentioned. They are certain compounds of the earths, silica, lime, alumina, magnesia, and of the oxides of iron and manganesum; animal and vegetable matters in a decomposing state, and saline, acid, or alkaline combinations.

In all chemical experiments on the composition of soils connected with agriculture, the constituent parts obtained are compounds; and they act as compounds in nature; it is in this state, therefore, that I shall describe their characteristic properties.

1. *Silica*, or the earth of *flints*, in its pure and crystallized form, is the substance known by the name of rock crystal, or Cornish diamond. As it is procured by chemists, it appears in the form of a white impalpable powder. It is not soluble in the common acids, but dissolves by heat in fixed alkaline lixivia. It is an incombustible substance, for it is saturated with oxygen. I have proved it to be a compound of oxygen and the peculiar combustible body which I have named silicum; and from the experiments of Berzelius, it is probable that it contains nearly equal weights of these two elements.*

2. The sensible properties of *lime* are well known. It exists in soils usually united to carbonic acid, which is easily disengaged from it by the attraction of the common acids. It is sometimes found combined with the phosphoric and sulphuric acids. Its chemical properties and agencies in its pure state will be described in the lecture on manures, obtained from the mineral kingdom. It is soluble in nitric and muriatic acids, and forms a substance with sulphuric acid difficult of solution, called gypsum. It is not soluble in alkaline solutions. It consists of one proportion. 40 of the peculiar metallic substance, which I have named calcium; and one proportion 15 of oxygen.

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*For the following note on this subject I am indebted to the kindness of the Right Hon. Sir Joseph Banks, Bart. K. B.:—

Information received from John Jeffrey, Esq., his Majesty's Consul-General at Lisbon, in answer to Queries transmitted to him, from the Comm. of P. C. for Trade, dated Jan. 12, 1812.

To grind hard corn with the mill-stones used in England, the wheat must be well screened, then sprinkled with water at the miller's discretion, and laid in heaps and frequently turned and thoroughly mixed, which will soften the husk, so as to make it separate from the flour in grinding, and of course give the flour a brighter colour; otherwise the flinty quality of the wheat, and the thinness of the skin, will prevent its separation, and will render the flour unfit for making into bread.

I am informed by a miller of considerable experience, and who works his mills entirely with the stones from England or Ireland, that he frequently prepares the hard Barbary corn by immersing it in water in close wicker baskets, and spreading it thinly on a floor to dry; much depends on the judgment and skill of the miller in preparing the corn for the mill according to its relative quality. I beg to observe, that it is not from this previous process of wetting the corn that the weight in the flour of hard corn is increased; but from its natural quality it imbibes considerably more water in making it into bread. The mill-stones must not be cut too deep, but the furrows very fine, and picked in the usual way. The mills should work with less velocity in grinding hard corn than with soft, and set to work at first with soft corn, till the mill ceases to work well; then put on the hard corn. Hard wheat always sells at a higher price in the market than soft wheat, on an average of ten to fifteen per cent.; as it produces more flour in proportion, and less bran than the soft corn.

Flour made from hard wheat is more esteemed than what is made from soft corn; and both sorts are applied to every purpose.

The flour of hard wheat is in general superior to that made from soft; and there is no difference in the process of making them into bread; but the flour from hard wheat will imbibe and retain more water in making into bread, and will consequently produce more weight of bread: it is the practice here, and which I am persuaded it would be advisable to adopt in England, to make bread with flour of hard and soft wheat, which by being mixed, will make the bread much better.

(Signed) JOHN JEFFREY.

* According to the later experiments of Berzelius, silica consists of 48·4 inflammable basis, and of 51·6 oxygen.—J. D.

3. *Atumina* exists in a pure and crystallized state in the white sapphire, and united to a little oxide of iron and silica in the other oriental gems.

In the state in which it is procured by chemists, it appears as a white powder, soluble in acids and fixed alkaline liquors. From my experiments, it appears that alumina consists of one proportion 33 of aluminum, and one 15 of oxygen.

4. *Magnesia* exists in a pure crystallized state, constituting a mineral like talc found in North America. In its common form it is the *magnesia usta*, or calcined magnesia of druggists. It generally exists in soils combined with carbonic acid. It is soluble in all the mineral acids; but not in alkaline lixivia. It is distinguished from the other earths found in soils by its ready solubility in solutions of alkaline carbonates, saturated with carbonic acid. It appears to consist of 38 magnesium and 15 oxygen.

5. There are two well-known *oxides of iron*, the black and the brown. The black is the substance that flies off when red-hot iron is hammered. The brown oxide may be formed by keeping the black oxide red-hot for a long time in contact with air. The first seems to consist of one proportion of iron 103, and two of oxygen 30: and the second of one proportion of iron 103, and three proportions of oxygen 45. The oxides of iron sometimes exist in soils combined with carbonic acid. They are easily distinguished from other substances by their giving, when dissolved in acids, a black color to solution of galls, and a bright blue precipitate to solution of prussiate of potassa and iron.

6. *The oxide of manganesum* is the substance commonly called manganese, and used in bleaching. It appears to be composed of one proportion of manganesum 113, and three of oxygen 45. It is distinguished from the other substances found in soils, by its property of decomposing muriatic acid, and converting it into chlorine.

7. *Vegetable and animal matters* are known by their sensible qualities, and by their property of being decomposed by heat. Their characters may be learned from the details in the last lecture.

8. The *saline compounds* found in soils, are common salt, sulphate of magnesia, sometimes sulphate of iron, nitrates of lime and of magnesia, sulphate of potassa, and carbonates of potassa and soda.* To describe their characters minutely will be unnecessary: the tests for most of them have been already noticed.

The silica in soils is usually combined with alumina and oxide of iron, or with alumina, lime, magnesia, and oxide of iron, forming gravel and sand of different degrees of fineness. The carbonate of lime is usually in an impalpable form; but sometimes in the state of calcareous sand. The magnesia, if not combined in the gravel and sand of soil, is in a fine powder united to carbonic acid. The impalpable part of the soil, which is usually called clay or loam, consists of silica, alumina, lime, and magnesia; and is, in fact, usually of the same composition as the hard sand, but more finely divided. The vegetable or animal matters (and the first is by far the most common in soils), exist in different states of decomposition. They are sometimes fibrous, sometimes entirely broken down and mixed with the soil.

To form a just idea of soils, it is necessary to conceive different rocks decomposed, or ground into parts and powder of different degrees of fineness, some of their soluble parts dissolved by water, and that water adhering to the mass, and the whole mixed with larger or smaller quantities of the remains of vegetables and animals in different stages of decay.

It will be necessary to describe the processes by which all the varieties of soils may be analyzed. I shall be minute in these particulars, and, I fear, tedious; but the philosophical farmer will, I trust, feel the propriety of full details on this subject.

The instruments required for the analysis of soils are few, and but little expensive. They are, a balance capable of containing a quarter of a pound of common soil, and capable of turning when loaded with a grain; a set of weights from a quarter of a pound troy to a grain; a wire sieve, sufficiently coarse to admit a mustard seed through its apertures; an Argand lamp and stand; some glass bottles; Hessian crucibles; procelain, or queen's ware evaporating basins; a Wedgewood pestle and mortar; some filters made of half a sheet of blotting paper, folded so as to contain a pint of liquid, and greased at the edges; a bone knife, and an apparatus for collecting and measuring aëriform fluids.

The chemical substances or re-agents required for separating the constituent parts of the soil, have, for the most part, been mentioned before; they are muriatic acid *(spirit of salt,)* sulphuric acid, pure volatile alkali dissolved in water, solution of prussiate of potash and iron, succinate of ammonia, soap lie, or solution of potassa, solutions of carbonate of ammonia, or muriate of ammonia, of neutral carbonate of potash, and nitrate of ammoniac.

In cases when the general nature of the soil of a field is to be ascertained, specimens of it should be taken from different places, two or three inches below the surface, and examined as to the similarity of their properties. It sometimes happens, that upon plains the whole of the upper stratum of the land is of the same kind, and in this case one analysis will be sufficient; but in valleys, and near the beds of rivers, there are very great differences, and it now and then occurs that one part of a field is calcareous, and another part siliceous; and in this case, and in analogous cases, the portions different from each other should be separately submitted to experiment.

Soils, when collected, if they cannot be immediately examined, should be preserved in phials quite filled with them, and closed with ground-glass stoppers.

The quantity of soil most convenient for a perfect analysis, is from two to four hundred grains. It should be collected in dry weather, and exposed to the atmosphere till it becomes dry to the touch.

The specific gravity of a soil, or the relation of its weight to that of water, may be ascertained by introducing into a phial, which will contain a known quantity of water, equal volumes of water and of soil; and this may be easily done by pouring in water till it is half full, and then adding the soil till the fluid rises to the mouth; the difference

* In some soils, especially in Spain and in Bengal, nitre is an ingredient formed by the intervention of carbonate of lime, by the union of alkali in the soil, and of nitric acid, the elements of which are derived from the atmosphere.—J. D.

between the weight of the soil and that of the water will give the result.* Thus, if the bottle contains four hundred grains of water, and gains two hundred grains when half filled with water and half with soil, the specific gravity of the soil will be 2; that is, it will be twice as heavy as water; and if it gained 165 grains, its specific gravity would be 1825, water being 1000.

It is of importance that the specific gravity of a soil should be known, as it affords an indication of the quantity of animal and vegetable matter it contains; these substances being always most abundant in the lighter soils.

The other physical properties of soils should likewise be examined before the analysis is made, as they denote, to a certain extent, their composition, and serve as guides in directing the experiments. Thus, siliceous soils are generally rough to the touch, and scratch glass when rubbed upon it; ferruginous soils are of a red or yellow colour; and calcareous soils are soft.†

1. Soils, though as dry as they can be made by continued exposure to air, in all cases still contain a considerable quantity of water, which adheres with great obstinacy to the earths and animal and vegetable matter, and can only be driven off from them by a considerable degree of heat. The first process of analysis is, to free the given weight of soil from as much of this water as possible, without in other respects affecting its composition; and this may be done by heating it for ten or twelve minutes over an Argand's lamp, in a basin of porcelain, to a temperature equal to 300 Fahrenheit; and if a thermometer is not used, the proper degree may be easily ascertained, by keeping a piece of wood in contact with the bottom of the dish; as long as the color of the wood remains unaltered, the heat is not too high; but when the wood begins to be charred, the process must be stopped. A small quantity of water will, perhaps, remain in the soil even after this operation, but it always affords useful comparative results; and if a higher temperature were employed, the vegetable or animal matter would undergo decomposition, and in consequence the experiment be wholly unsatisfactory.

The loss of weight in the process should be carefully noted, and when in 400 grains of soil it reaches as high as 50, the soil may be considered as in the greatest degree absorbent, and retentive of water, and will generally be found to contain much vegetable or animal matter, or a large proportion of aluminous earth. When the loss is only from 20 to 10, the land may be considered as only slightly absorbent and retentive, and siliceous earth probably forms the greatest part of it.

2. None of the loose stones, gravel, or large vegetable fibres, should be divided from the pure soil till after the water is drawn off; for these bodies are themselves often highly absorbent and retentive, and, in consequence, influence the fertility of the land. The next process, however, after that of heating, should be their separation, which may be easily accomplished by the sieve, after the soil has been gently bruised in a mortar. The weights of the vegetable fibres or wood, and of gravel and stones, should be separately noted down, and the nature of the last ascertained; if calcareous, they will effervesce with acids; if siliceous, they will be sufficiently hard to scratch glass; and if of the common aluminous class of stones, they will be soft, easily cut with a knife, and incapable of effervescing with acids.

3. The greater number of soils, besides gravel and stones, contain larger or smaller proportions of sand of different degrees of fineness; and it is a necessary operation, the next in the process of analysis, to detach them from the parts in a state of more minute division, such as clay, loam, marl, vegetable and animal matter, and the matter soluble in water. This may be effected in a way sufficiently accurate, by boiling the soil in three or four times its weight of water; and when the texture of the soil is broken down, and the water cool, by agitating the parts together, and then suffering them to rest. In this case, the coarse sand will generally separate in a minute, and the finer in two or three minutes, whilst the highly-divided earthy, animal, or vegetable matter, will remain in a state of mechanical suspension for a much longer time; so that by pouring the water from the bottom of the vessel, after one, two, or three minutes, the sand will be principally separated from the other substances, which, with the water containing them, must be poured into a filter, and after the water has passed through, collected, dried, and weighed. The sand must likewise be weighed, and the respective quantities noted down. The water of lixiviation must be preserved, as it will be found to contain the saline and soluble animal or vegetable matters, if any exist in the soil.

4. By the process of washing and filtration, the soil is separated into two portions, the most important of which is generally the finely-divided matter. A minute analysis of the sand is seldom or never necessary, and its nature may be detected in the same manner as that of the stones or gravel. It is always either siliceous sand, or calcareous sand, or a mixture of both. If it consist wholly of carbonate of lime, it will be rapidly soluble in muriatic acid with effervescence; but if it consist partly of this substance, and party of siliceous matter, the respective quantities may be ascertained by weighing the residuum after the action of the acid, which must be applied till the mixture has acquired a sour taste, and has ceased to effervesce. This residuum is the siliceous part; it must be washed, dried, and heated strongly in a crucible; the difference between the weight of it and the weight of the whole indicates the proportion of calcareous sand.

5. The finely-divided matter of the soil is usually very compound in its nature; it sometimes contains all the four primitive earths of soils, as well as animal and vegetable matter; and to ascertain the proportions of these with tolerable accuracy is the most difficult part of the subject.

The first process to be performed in this part of the analysis is the exposure of the fine matter of the soil to the action of muriatic acid. This substance should be poured upon the earthy matter in an evaporating basin, in a quantity equal to twice the weight of the earthy matter; but diluted with double its volume of water. The mixture should

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*It may be more accurately and easily accomplished by weighing it in air and in water in a light phial carefully counterpoised.—J. D.

†Clay soils, breathed on, emit a peculiar odor, called the earthy.—J. D.

be often stirred, and suffered to remain for an hour, or an hour and a half, before it is examined.

If any carbonate of lime or of magnesia exist in the soil, they will have been dissolved in this time by the acid, which sometimes takes up likewise a little oxide of iron; but very seldom any alumina.

The fluid should be passed through a filter; the solid matter collected, washed with rain water, dried at a moderate heat, and weighed. Its loss will denote the quantity of solid matter taken up. The washings must be added to the solution, which, if not sour to the taste, must be made so by the addition of fresh acid, when a little solution of prussiate of potassa and iron must be mixed with the whole. If a blue precipitate occurs, it denotes the presence of oxide of iron, and the solution of the prussiate must be dropped in till no farther effect is produced. To ascertain its quantity, it must be collected in the same manner as other solid precipitates, and heated red; the result is oxide of iron, which may be mixed with a little oxide of manganesum.

Into the fluid freed from oxide of iron, a solution of neutralized carbonate of potash must be poured, till all effervescence ceases in it, and till its taste and smell indicate a considerable excess of alkaline salt.

The precipitate that falls down is carbonate of lime; it must be collected on the filter, and dried at a heat below that of redness.

The remaining fluid must be boiled for a quarter of an hour, when the magnesia, if any exist, will be precipitated from it, combined with carbonic acid, and its quantity is to be ascertained in the same manner as that of the carbonate of lime.

If any minute proportion of alumina should, from peculiar circumstances, be dissolved by the acid, it will be found in the precipitate with the carbonate of lime, and it may be separated from it by boiling it for a few minutes with soap lie, sufficient to cover the solid matter: this substance dissolves alumina, without acting upon carbonate of lime.

Should the finely-divided soil be sufficiently calcareous to effervesce very strongly with acids, a very simple method may be adopted for ascertaining the quantity of carbonate of lime, and one sufficiently accurate in all common cases.

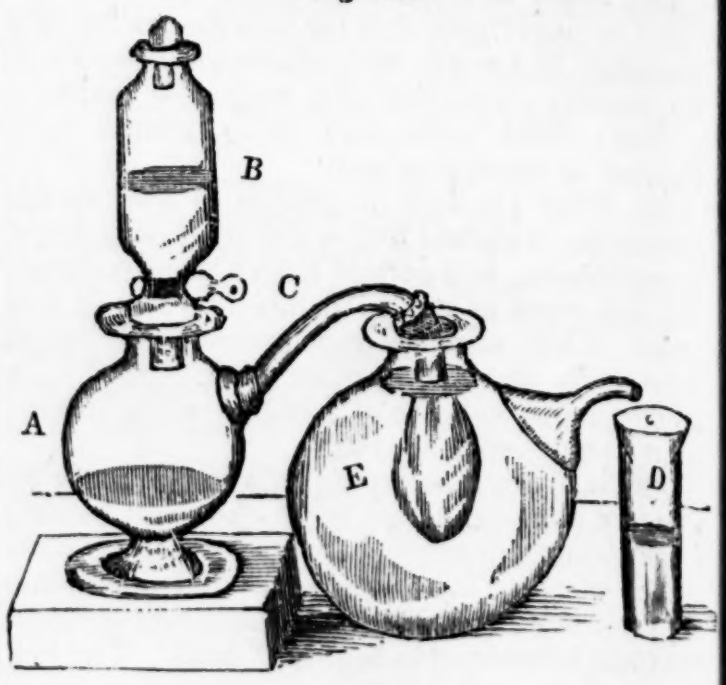
Carbonate of lime, in all its states, contains a determinate proportion of carbonic acid, *i. e.* nearly 43 per cent., so that when the quantity of this elastic fluid given out by any soil during the solution of its calcareous matter in an acid is known, either in weight or measure, the quantity of carbonate of lime may be easily discovered.

When the process by diminution of weight is employed, two parts of the acid and one part of the matter of the soil must be weighed in two separate bottles, and very slowly mixed together till the effervescence ceases: the difference between their weight before and after the experiment denotes the quantity of carbonic acid lost; for every four grains and a quarter of which, ten grains of carbonate of lime must be estimated.

The best method of collecting the carbonic acid, so as to discover its volume, is by a peculiar pneumatic apparatus,* in which its bulk may be measured by the quantity of water it displaces.

6. After the calcareous parts of the soil have been acted upon by muriatic acid, the next process is to ascertain the quantity of finely-divided insoluble animal and vegetable matter that it contains.

Fig. 15.



This may be done with sufficient precision, by strongly igniting it in a crucible over a common fire till no blackness remains in the mass. It should be often stirred with a metallic rod, so as to expose new surfaces continually to the air; the loss of weight that it undergoes denotes the quantity of the substance that it contains destructible by fire and air.*

It is not possible, without very refined and difficult experiments, to ascertain whether this substance is wholly animal or vegetable matter, or a mixture of both. When the smell emitted during the incineration is similar to that of burnt feathers, it is a certain indication of some substance either animal or analogous to animal matter; and a copious blue flame at the time of ignition almost

* Fig. 15. A, B, C, D, represent the different parts of this apparatus. A represents the bottle for receiving the soil. B the bottle containing the acid, furnished with a stop-cock. C the tube connected with a flaccid bladder. D the graduated measure. E the bottle for containing the bladder. When this instrument is used, a given quantity of soil is introduced into A. B is filled with muriatic acid diluted with an equal quantity of water; and the stop-cock being closed, is connected with the upper orifice of A, which is ground to receive it. The tube D is introduced into the lower orifice of A, and the bladder connected with it placed in its flaccid state into E, which is filled with water. The graduated measure is placed under the tube of E. When the stop-cock of B is turned, the acid flows into A, and acts upon the soil; the elastic fluid generated passes through C into the bladder, and displaces a quantity of water in E equal to it in bulk, and this water flows through the tube into the graduated measure; and gives by its volume the indication of the proportion of carbonic acid disengaged from the soil; for every ounce measure of which two grains of carbonate of lime may be estimated.

* When the soil is aluminous, part of the loss in the above process will be owing to water driven off. Pure hydrate of alumina contains about 58 per cent. water; the whole of which can only be expelled by a white heat. On this account the ascertaining with any accuracy the proportion of animal and vegetable matter in a soil is difficult, and requires much chemical skill.—J. D.

always denotes a considerable proportion of vegetable matter. In cases when it is necessary that the experiments should be very quickly performed, the destruction of the decomposable substances may be assisted by the agency of nitrate of ammoniac, which at the time of ignition may be thrown gradually upon the heated mass, in the quantity of twenty grains for every hundred of residual soil. It accelerates the dissipation of the animal and vegetable matter, which it causes to be converted into elastic fluids; and it is itself at the same time decomposed and lost.

7. The substances remaining after the destruction of the vegetable and animal matter are generally minute particles of earthy matter, containing usually alumina and silica, with combined oxide of iron, or of manganesum.

To separate these from each other, the solid matter should be boiled for two or three hours with sulphuric acid, diluted with four times its weight of water: the quantity of the acid should be regulated by the quantity of solid residuum to be acted on, allowing for every 100 grains 2 drachms or 120 grains of acid.

The substance remaining after the action of the acid may be considered as siliceous; and it must be separated, and its weight ascertained, after washing and drying in the usual manner.

The alumina and the oxide of iron and manganesum, if any exist, are all dissolved by the sulphuric acid: they may be separated by succinate of ammonia, added to excess, which throws down the oxide of iron; and by soap lie, which will dissolve the alumina, but not the oxide of manganesum; the weights of the oxides ascertained after they have been heated to redness will denote their quantities.

Should any magnesia and lime have escaped solution in the muriatic acid, they will be found in the sulphuric acid; this, however, is rarely the case; but the process for detecting them and acertaining their quantities, is the same in both instances.

The method of analysis by sulphuric acid is sufficiently precise for all usual experiments; but if very great accuracy be an object, dry carbonate of potassa must be employed as the agent, and the residuum of the incineration (6) must be heated red for half an hour, with four times its weight of this substance, in a crucible of silver, or of well-baked porcelain. The mass obtained must be dissolved in muriatic acid, and the solution evaporated till it is nearly solid; distilled water must then be added, by which the oxide of iron and all the earths, except silica, will be dissolved in combination as muriates. The silica, after the usual process of lixiviation, must be heated red; the other substances may be separated in the same manner as from the muriatic and sulphuric solutions.

This process is the one usually employed by chemical philosophers for the analysis of stones.

8. If any saline matter, or soluble vegetable or animal matter is suspected in the soil, it will be found in the water of lixiviation used for separating the sand.

This water must be evaporated to dryness in a proper dish, at a heat below its boiling point.

If the solid matter obtained is of a brown color and inflammable, it may be considered as partly vegetable extract. If its smell, when exposed to heat, be like that of burnt feathers, it contains animal or albuminous matter; if it be white, crystalline, and not destructible by heat, it may be considered as principally saline matter; the nature of which may be known by the tests already described.

9. Should sulphate or phosphate of lime be suspected in the entire soil, the detection of them requires a particular process upon it. A given weight of it, for instance, 400 grains, must be heated red for half an hour in a crucible, mixed with one-third of powdered charcoal. The mixture must be boiled for a quarter of an hour, in a-half pint of water, and the fluid collected through the filter, and exposed for some days to the atmosphere in an open vessel. If any notable quantity of sulphate of lime *(gypsum)* existed in the soil, a white precipitate will gradually form in the fluid, and the weight of it will indicate the proportion.

Phosphate of lime, if any exist, may be separated from the soil after the process for gypsum. Muriatic acid must be digested upon the soil, in quantity more than sufficient to saturate the soluble earths; the solution must be evaporated, and water poured upon the solid matter. This fluid will dissolve the compounds of earths with the muriatic acid, and leave the phosphate of lime untouched. It would not fall within the limits assigned to this lecture to detail any processes for the detection of substances which may be accidentally mixed with the matters of soils. Other earths and metallic oxides are now and then found in them, but in quantities too minute to bear any relation to fertility or barrenness, and the search for them would make the analysis much more complicated, without rendering it more useful.

10. When the examination of a soil is completed, the products should be numerically arranged, and their quantities added together; and if they nearly equal the original quantity of soil, the analysis may be considered as accurate. It must, however, be noticed, that when phosphate or sulphate of lime is discovered by the independent process just described (9), a correction must be made for the general process, by subtracting a sum equal to their weight from the quantity of carbonate of lime obtained by precipitation from the muriatic acid.

In arranging the products, the form should be in the order of the experiments by which they were procured.

Thus, I obtained from 400 grains of a good siliceous sandy soil from a hop-garden near Tunbridge, Kent,

	Grains.
Of water of absorption - -	19
Of loose stones and gravel, principally siliceous - - - -	53
Of undecompounded vegetable fibres -	14
Of fine siliceous sand - - -	212
Of minutely divided matter separated by agitation and filtration, and consisting of	
Carbonate of lime - - 19	
Carbonate of magnesia - 3	
Matter destructible by heat, principally vegetable - - - 15	
Silica - - - - 21	
Alumina - - - 13	
Oxide of iron - - - 5	

Soluble matter, principally common salt and vegetable extract	-	3	
Gypsum	- - -	2	
		—	81
Amount of all the products			379
Loss	- -		21

The loss in this analysis is not more than usually occurs, and it depends upon the impossibility of collecting the whole quantities of the different precipitates, and upon the presence of more moisture than is accounted for in the water of absorption. and which is lost in the different processes.

When the experimenter is become acquainted with the use of the different instruments, the properties of the re-agents, and the relations between the external and chemical qualities of soils, he will seldom find it necessary to perform, in any one case, all the processes that have been described. When his soil, for instance, contains no notable proportion of calcareous matter, the action of the muriatic acid (7) may be omitted. In examining peat soils, he will principally have to attend to the operation by fire and air (8): in the analysis of chalks and loams, he will often be able to omit the experiment by sulphuric acid (9); and when a soil is extremely dense and heavy, and after being heated to redness, strongly attracted by the magnet, he must particularly attend to the quantity of iron it contains; and, in this case, the muriatic acid will be the principal agent.

In the first trials that are made by persons unacquainted with chemistry, they must not expect much precision of result. Many difficulties will be met with; but in overcoming them, the most useful kind of practical knowledge will be obtained; and nothing is so instructive in experimental science as the detection of mistakes. The correct analyst ought to be well grounded in general chemical information; but, perhaps, there is no better mode of gaining it, than that of attempting original investigations. In pursuing his experiments, he will be continually obliged to learn the properties of the substances he is employing or acting upon; and his theoretical ideas will be more valuable in being connected with practical operations, and acquired for the purpose of discovery.

Plants, being possessed of no locomotive powers, can grow only in places where they are supplied with food; and the soil is necessary to their existence, both as affording them nourishment and enabling them to fix themselves in such a manner as to obey those mechanical laws by which their radicles are kept below the surface, and their leaves exposed to the free atmosphere. As the systems of roots, branches, and leaves are very different in different vegetables, so they flourish most in different soils; the plants that have bulbous roots, require a looser and a lighter soil than such as have fibrous roots; and the plants possessing only short fibrous radicles demand a firmer soil than such as have tap roots, or extensive lateral roots.

A good turnip soil from Holkham, Norfolk, afforded me 8 parts out of 9 siliceous sand; and the finely divided matter consisted

Of carbonate of lime	- -	63
— silica	- - - -	15
— alumina	- - -	11
— oxide of iron	- -	3
Of vegetable and saline matter	-	5
— moisture	- - -	3

I found the soil taken from a field at Sheffield Place, in Sussex, remarkable for producing flourishing oaks, to consist of six parts of sand, and one part of clay and finely divided matter. And 100 parts of the entire soil submitted to analysis produced,

Silica	- - - - 54
Alumina	- - - 28
Carbonate of lime	- - 3
Oxide of iron	- - - 5
Decomposing vegetable matter	- 4
Moisture and loss	- - - 6

An excellent wheat soil from the neighborhood of West Drayton, Middlesex, gave 3 parts in 5 of siliceous sand; and the finely divided matter consisted of

Carbonate of lime	- - 28
Silica	- - - - 32
Alumina	- - - 29
Animal or vegetable matter and moisture	11

Of these soils the last was by far the most, and the first the least, coherent in texture. In all cases the constituent parts of the soil which give tenacity and coherence are the finely divided matters; and they possess the power of giving those qualities the highest degree when they contain much alumina. A small quantity of finely divided matter is sufficient to fit a soil for the production of turnips and barley; and I have seen a tolerable crop of turnips on a soil containing 11 parts out of 12 sand. A much greater proportion of sand, however, always produces absolute sterility. The soil of Bagshot heath, which is entirely devoid of vegetable covering, contains less than one-twentieth of finely divided matter. 400 parts of it, which had been heated red, afforded me 380 parts of coarse siliceous sand, 9 parts of fine siliceous sand, and 11 parts of impalpable matter, which was a mixture of ferruginous clay with carbonate of lime.* Vegetable or animal matters, when finely divided, not only give coherence, but likewise softness and penetrability; but neither they nor any other part of the soil must be in too great proportion; and a soil is unproductive if it consist entirely of impalpable matter.

Pure alumina or silica, pure carbonate of lime,

* When the climate is favorable and there is sufficient moisture, shrubs occasionally grow and flourish in soils nearly purely siliceous. As a striking example, I may mention the soil of the cinnamon garden in the neighborhood of Colombo, in the island of Ceylon. In many spots where this valuable plant flourishes most, the surface of the ground is white as snow, being pure quartz-sand; below the surface a few inches, where the roots penetrate, the sand is of a gray color. A specimen of this, dried thoroughly, was found to consist of

98·5	Siliceous sand
1·0	Vegetable matter
0·5	Water.

In my work, entitled "An Account of the Interior of Ceylon," other instances are given of soils, composed chiefly of siliceous earths, admitting of cultivation in that climate. Reflecting on this, I am disposed to think that in estimating the power of a soil, in relation to fertility, great attention should be paid to situation, in connexion with water. Probably a nearly pure siliceous soil may be fertile which admits of being well watered, care being taken to give it manure. *Vide* p. 622.—J. D.

or carbonate of magnesia, are incapable of supporting healthy vegetation.

No soil is fertile that contains as much as 19 parts out of 20 of any of the constituents that have been mentioned.

It will be asked, are the pure earths in the soil merely active as mechanical or indirect chemical agents, or do they actually afford food to the plant? This is an important question; and not difficult of solution.

The earths consist, as I have before stated, of metals, united to oxygen; and these metals have not been decomposed; there is consequently no reason to suppose that the earths are convertible into the elements of organized compounds, into carbon, hydrogen, and azote.

Plants have been made to grow in given quantities of earth. They consume very small portions only, and what is lost may be accounted for by the quantities found in their ashes; that is to say, it has not been converted into any new products.

The carbonic acid united to lime or magnesia, if any stronger acid happens to be formed in the soil during the fermentation of vegetable matter, which will disengage it from the earths, may be decomposed: but the earths themselves cannot be supposed convertible into other substances by any process taking place in the soil.

In all cases, the ashes of plants contain some of the earths of the soil in which they grow; but these earths, as may be seen from the table of the ashes afforded by different plants given in the last Lecture, never equal more than $\frac{1}{50}$ of the weight of the plant consumed.

If they be considered as necessary to the vegetable, it is as giving hardness and firmness to its organization. Thus, it has been mentioned that wheat, oats, and many of the hollow grasses, have an epidermis principally of siliceous earth; the use of which seems to be to strengthen them, and defend them from the attacks of insects and parasitical plants.

Many soils are popularly distinguished as *cold;* and the distinction, though at first view it may appear to be founded on prejudice, is really just.

Some soils are much more heated by the rays of the sun, all other circumstances being equal, than others; and soils brought to the same degree of heat cool in different times, *i. e.* some cool much faster than others.

This property has been very little attended to in a philosophical point of view; yet it is of the highest importance in agriculture. In general, soils that consist principally of a stiff white clay are difficultly heated; and being usually very moist, they retain their heat only for a short time. *Chalks* are similar in one respect, that they are difficultly heated; but being drier they retain their heat longer, less being consumed in causing the evaporation of their moisture.

A black soil, containing much soft vegetable matter, is most heated by the sun and air; and the colored soils, and the soils containing much carbonaceous matter, or ferruginous matter, exposed under equal circumstances to the sun, acquire a much higher temperature than pale-colored soils.

When soils are perfectly dry, those that most readily become heated by the solar rays likewise cool most rapidly, their power of losing heat by radiation being greatest; but I have ascertained, by experiment, that the darkest colored dry soil, (that which contains abundance of animal or vegetable matter, substances which most facilitate the diminution of temperature,) when heated to the same degree, provided it be within the common limits of the effect of solar heat, will cool more slowly than a wet pale soil, entirely composed of earthy matter.

I found that a rich black mould, which contained nearly $\frac{1}{4}$ of the vegetable matter, had its temperature increased in an hour from 65° to 88° by exposure to sunshine; whilst a chalk soil was heated only to 69° under the same circumstances. But the mould removed into the shade, where the temperature was 62°, lost, in half an hour, 15°; whereas the chalk, under the same circumstances, had lost only 4°.

A brown fertile soil and a cold barren clay were each artificially heated to 88°, having been previously dried: they were then exposed in a temperature of 57°; in half an hour the dark soil was found to have lost 9° of heat; the clay had lost only 6°. An equal portion of the clay containing moisture, after being heated to 88°, was exposed in a temperature of 55°; in less than a quarter of an hour, it was found to have gained the temperature of the room. The soils in all these experiments were placed in small tin plate trays two inches square, and half an inch in depth, and the temperature ascertained by a delicate thermometer.

Nothing can be more evident than that the genial heat of the soil, particularly in spring, must be of the highest importance to the rising plant. And when the leaves are fully developed, the ground is shaded, and any injurious influence, which in the summer might be expected from too great a heat, entirely prevented; so that the temperature of the surface, when bare and exposed to the rays of the sun, affords at least one indication of the degrees of its fertility; and the thermometer may be sometimes a useful instrument to the purchaser or improver of lands.

There is a very simple test of the cooling or radiating powers of soils, the formation of dew upon them, or their relative increase of weight by exposure to the air after being dried, in the day or the night, in sunshine or in shade. The soil that radiates most heat acquires the greatest increase of weight; and of course the radiating powers of the soil are not only connected with its temperature, but likewise with its relations to moisture.

The moisture in the soil influences its temperature; and the manner in which it is distributed through, or combined with, the earthy materials, is of great importance in relation to the nutriment of the plant. If water is too strongly attracted by the earths, it will not be absorbed by the roots of the plants; if it is in too great quantity, or too loosely united to them, it tends to injure or destroy the fibrous parts of the roots.

There are two states in which water seems to exist in the earths, and in animal and vegetable substances: in the first state it is united by chemical, in the other by cohesive, attraction.

If pure solution of ammonia or potassa be poured into a solution of alum, alumina falls down combined with water; and the powder dried by exposure to air will afford more than half its weight of water by distillation; in this instance the water

is united by chemical attraction. The moisture which wood, or muscular fibre, or gum, that have been heated to 212°, afford by distillation at a red heat, is likewise water, the elements of which were united in the substance by chemical combination.

When pipe-clay dried at the temperature of the atmosphere is brought in contact with water, the fluid is rapidly absorbed: this is owing to cohesive attraction. Soils in general, vegetable and animal substances, that have been dried at a heat below that of boiling water, increase in weight by exposure to air, owing to their absorbing water existing in the state of vapor in the air, in consequence of cohesive attraction.

The water *chemically combined* amongst the elements of soils, unless in the case of the decomposition of animal or vegetable substances, cannot be absorbed by the roots of plants; but that *adhering* to the parts of the soil is in constant use in vegetation. Indeed, there are few mixtures of the earths found in soils that contain any chemically combined water; water is expelled from the earths by most substances that combine with them. Thus, if a combination of lime and water be exposed to carbonic acid; the carbonic acid takes the place of water; and compounds of alumina and silica, or other compounds of the earths, do not chemically unite with water; and soils, as it has been stated, are formed either by earthy carbonates, or compounds of the pure earths and metallic oxides.

When saline substances exist in soils, they may be united to water both chemically and mechanically; but they are always in too small a quantity to influence materially the relations of the soil to water.

The power of the soil to absorb water by cohesive attraction depends in great measure upon the state of division of its parts; the more divided they are, the greater is their absorbent power. The different constituent parts of soils likewise appear to act, even by cohesive attraction, with different degrees of energy. Thus vegetable substances seem to be more absorbent than animal substances; animal substances more so than compounds of alumina and silica; and compounds of alumina and silica more absorbent than carbonates of lime and magnesia: these differences may, however, possibly depend upon the differences in their state of division, and upon the surface exposed.

The power of soils to absorb water from air is much connected with fertility. When this power is great, the plant is supplied with moisture in dry seasons; and the effect of evaporation in the day is counteracted by the absorption of aqueous vapor from the atmosphere, by the interior parts of the soil during the day, and by both the exterior and interior during the night.

The stiff clays approaching to pipe clays in their nature, which take up the greatest quantity of water when it is poured upon them in a fluid form, are not the soils which absorb most moisture from the atmosphere in dry weather. They cake, and present only a small surface to the air; and the vegetation on them is generally burnt up almost as readily as on sands.

The soils that are most efficient in supplying the plant with water by atmospheric absorption are those in which there is a due mixture of sand, finely divided clay, and carbonate of lime, with some animal or vegetable matter; and which are so loose and light as to be freely permeable to the atmosphere. With respect to this quality, carbonate of lime and animal and vegetable matter are of great use in soils, they give absorbent power to the soil without giving it likewise tenacity: sand, which also destroys tenacity, on the contrary, gives little absorbent power.

I have compared the absorbent powers of many soils with respect to atmospheric moisture, and I have always found it greatest in the most fertile soils; so that it affords one method of judging of the productiveness of land.

1000 parts of a celebrated soil from Ormistown, in East Lothian, which contained more than half its weight of finely divided matter, of which 11 parts were carbonate of lime and 9 parts vegetable matter, when dried at 212°, gained in an hour by exposure to air saturated with moisture, at temperature 62°, 18 grains.

1000 parts of a very fertile soil from the banks of the river Parret, in Somersetshire, under the same circumstances, gained 16 grains.

1000 parts of a soil from Mersea, in Essex, worth 45 shillings an acre, gained 13 grains.

1000 grains of a fine sand from Essex, worth 28 shillings an acre, gained 11 grains.

1000 of a coarse sand, worth 15 shillings an acre, gained only 8 grains.

1000 of the soil of Bagshot heath gained only 3 grains.

Water, and the decomposing animal and vegetable matter existing in the soil, constitute the true nourishment of plants: and as the earthy parts of the soil are useful in retaining water, so as to supply it in the proper proportions to the roots of the vegetables, so they are likewise efficacious in producing the proper distribution of the animal or vegetable matter: when equally mixed with it, they prevent it from decomposing too rapidly; and by their means the soluble parts are supplied in proper proportions.

Besides this agency, which may be considered as mechanical, there is another agency between soils and organizable matters, which may be regarded as chemical in its nature. The earths, and even the earthy carbonates, have a certain degree of chemical attraction for many of the principles of vegetable and animal substances. This is easily exemplified in the instance of alumina and oil; if an acid solution of alumina be mixed with a solution of soap, which consists of oily matter and potassa, the oil and the alumina will unite and form a white powder, which will sink to the bottom of the fluid.

The extract from decomposing vegetable matter, when boiled with pipe-clay or chalk, forms a combination by which the vegetable matter is rendered more difficult of decomposition and of solution. Pure silica and siliceous sands have little action of this kind; and the soils which contain the most alumina and carbonate of lime are those which act with the greatest chemical energy in preserving manures. Such soils merit the appellation which is commonly given to them of rich soils; for the vegetable nourishment is long preserved in them, unless taken up by the organs of plants. Siliceous sands, on the contrary, deserve the term hungry, which is commonly applied to them; for the vegetable and animal mat-

ters they contain not being attracted by the earthy constituent parts of the soil, are more liable to be decomposed by the action of the atmosphere, or carried off from them by water.

In most of the black and brown rich vegetable moulds, the earths seem to be in combination with a peculiar extractive matter, afforded during the decomposition of vegetables: this is slowly taken up, or attracted from the earths by water, and appears to constitute a prime cause of the fertility of the soil.

The standard of fertility of soils for different plants must vary with the climate; and must be particularly influenced by the quantity of rain.

The power of soils to absorb moisture ought to be much greater in warm or dry countries than in cold and moist ones; and the quantity of clay, or vegetable or animal matter they contain, greater. Soils also on declivities ought to be more absorbent than in plains or in the bottom of valleys. Their productiveness likewise is influenced by the nature of the sub-soil, or the stratum on which they rest.

When soils are immediately situated upon a bed of rock or stone, they are much sooner rendered dry by evaporation, than where the sub-soil is of clay or marl: and one cause of the great fertility of some lands in the moist climate of Ireland is the proximity of the rocky strata to the soil.

A clayey sub-soil will sometimes be of material advantage to a sandy soil; and in this case it will retain moisture in such a manner as to be capable of supplying that lost by the earth above, in consequence of evaporation, or the consumption of it by plants.

A sandy, or gravelly sub-soil, often corrects the imperfections of too great a degree of absorbent power in the true soil.

In calcareous countries, where the surface is a species of marl, the soil is often found only a few inches above the limestone; and its fertility is not impaired by the proximity of the rock: though in a less absorbent soil, this situation would occasion barrenness; and the sandstone and limestone hills in Derbyshire and North Wales may be easily distinguished at a distance in summer by the different tints of the vegetation. The grass on the sandstone hills usually appears brown and burnt up; that on the limestone hills, flourishing and green.

In devoting the different parts of an estate to the necessary crops, it is perfectly evident from what has been said, that no general principle can be laid down, except when all the circumstances of the nature, composition, and situation of the soil and sub-soil are known.

The methods of cultivation, likewise, must be different for different soils. The same practice, which will be excellent in one case, may be destructive in another.

Deep ploughing may be a very profitable practice in a rich thick soil; and in a fertile shallow soil, situated upon cold clay or sandy sub-soil, it may be extremely prejudicial.

In a moist climate, where the quantity of rain that falls annually, equals from 40 to 60 inches, as in Lancashire, Cornwall, and some parts of Ireland, a siliceous sandy soil is much more productive than in dry districts; and in such situations, wheat and beans will require a less coherent and absorbent soil than in drier situations; and plants having bulbous roots will flourish in a soil containing as much as 14 parts out of 15 of sand.

Even the exhausting powers of crops will be influenced by like circumstances. In cases where plants cannot absorb sufficient moisture, they must take up more manure. And in Ireland, Cornwall, and the Western Highlands of Scotland, corn will exhaust less than in dry inland situations. Oats, particularly in dry climates, are impoverishing in a much higher degree than in moist ones.

Soils appear to have been originally produced in consequence of the decomposition of rocks and strata. It often happens, that soils are found in an unaltered state upon the rocks from which they were derived. It is easy to form an idea of the manner in which rocks are converted into soils, by referring to the instance of *soft granite*, or *porcelain granite*. This substance consists of three ingredients, quartz, feldspar, and mica. The quartz is almost pure siliceous earth, in a crystalline form. The feldspar and mica are very compounded substances; both contain silica, alumina, and oxide of iron: in the feldspar there is usually lime and potassa; in the mica, lime and magnesia.

When a granitic rock of this kind has been long exposed to the influence of air and water, the lime and the potassa contained in its constituent parts are acted upon by water or carbonic acid; and the oxide of iron, which is almost always in its least oxided state, tends to combine with more oxygen; the consequence is, that the felpspar decomposes, and likewise the mica, but the first the most rapidly. The feldspar, which is as it were the cement of the stone, forms a fine clay: the mica partially decomposed, mixes with it as sand; and the undecomposed quartz appears as gravel, or sand of different degrees of fineness.

As soon as the smallest layer of earth is formed on the surface of a rock, the seeds of lichens, mosses, and other imperfect vegetables which are constantly floating in the atmosphere, and which have made it their resting-place, begin to vegetate; their death, decomposition, and decay, afford a certain quantity of organizable matter, which mixes with the earthy materials of the rock; in this improved soil more perfect plants are capable of subsisting; these in their turn, absorb nourishment from water and the atmosphere; and after perishing, afford new materials to those already provided: the decomposition of the rock still continues; and at length by such slow and gradual processes, a soil is formed in which even forest trees can fix their roots, and which is fitted to reward the labors of the cultivator.

In instances where successive generations of vegetables have grown upon a soil, unless part of their produce has been carried off by man, or consumed by animals, the vegetable matter increases in such a proportion that the soil approaches to a peat in its nature; and if in a situation where it can receive water from a higher district, it becomes spongy, and permeated with that fluid, and is gradually rendered incapable of supporting the nobler classes of vegetables.

Many peat-mosses seem to have been formed by the destruction of forests, in consequence of the imprudent use of the hatchet by the early cultivators of the country in which they exist: when the trees are felled in the outskirts of a wood,

those in the interior exposed to the influence of the winds, and having been accustomed to shelter, become unhealthy, and die in their new situation; and their leaves and branches gradually decomposing, produce a stratum of vegetable matter. In many of the great bogs in Ireland and Scotland, the larger trees that are found in the out-skirts of them bear the marks of having been felled. In the interior few entire trees are found; and the cause is, probably, that they fell by gradual decay; and that the fermentation and decomposition of the vegetable matter was most rapid where it was in the greatest quantity.

Lakes and pools of water are sometimes filled up by the accumulation of the remains of aquatic plants; and in this case a sort of spurious peat is formed. The fermentation in these cases, however, seems to be of a different kind. Much more gaseous matter is evolved; and the neighborhood of morasses in which aquatic vegetables decompose is usually aguish and unhealthy; whilst that of the true peat, or peat formed on soils originally dry, is always salubrious.*

The earthy matter of peats is uniformly analogous to that of the stratum on which they repose; the plants which have formed them must have derived the earths that they contained from this stratum. Thus in Wiltshire and Berkshire, where the stratum below the peat is chalk, calcareous earth abounds in the ashes, and very little alumina and silica. They likewise contain much oxide of iron and gypsum, both of which may be derived from the decomposition of the pyrites, so abundant in chalk.

Different specimens of peat that I have burnt, from the granitic and schistose soils of different parts of these islands, have always given ashes, principally siliceous and aluminous; and a specimen of peat from the county of Antrim, gave ashes which afforded very nearly the same constituents as the great basaltic stratum of the county.

Poor and hungry soils, such as are produced from the decomposition of granitic and sandstone rocks, remain very often for ages with only a thin covering of vegetation. Soils from the decomposition of limestone, chalks, and basalts, are often clothed by nature with the perennial grasses; and afford, when ploughed up, a rich bed of vegetation for every species of cultivated plant.

Rocks and strata from which soils have been derived, and those which compose the more interior solid parts of the globe, are arranged in a certain order; and as it often happens that strata very different in their nature are associated together, and that the strata immediately beneath the soil contain materials which may be of use for improving it, a general view of the nature and position of rocks and strata in nature will not, I trust, be unacceptable to the scientific farmer.

Rocks are generally divided by geologists into

Fig. 16.

two grand divisions, distinguished by the names of *primary and secondary*.

The primary rocks are composed of pure crystalline matter, and contain no fragments of other rocks.

The secondary rocks, or strata, consist only partly of crystalline matter, contain fragments of other rocks or strata; often abound in remains of vegetables and marine animals; and sometimes contain the remains of land animals.

The primary rocks are generally arranged in large masses, or in layers, vertical or more or less inclined to the horizon.

The secondary rocks are usually disposed in strata or layers, parallel, or nearly parallel, to the horizon.

The number of primary rocks which are commonly observed in nature are eight.

First, *granite*, which, as has been mentioned, is composed of quartz, feldspar, and mica; when these bodies are arranged in regular layers in the rock, it is called *gneiss*.

Second, *micaceous schistus*, which is composed of quartz and mica, arranged in layers, which are usually curvilineal.

Third, *sienite*, which consists of the substance called hornblende and feldspar.

* In tropical climates no peat is formed; the temperature is too high. The dead vegetable matter rapidly decomposes, and is converted into gases; and this probably is one of the causes of these climates being so much more unhealthy and productive of malaria-fevers than temperate and cold climates.—J. D.

Fourth, *serpentine*, which is constituted by feldspar and a body named resplendent hornblende; and their separate crystals are often so small as to give the stone a uniform appearance: this rock abounds in veins of a substance called *steatite*, or *soap rock*.

Fifth, *porphyry*, which consists of crystals of feldspar, embedded in the same material; but usually of a different color.

Sixth, *granular marble*, which consists entirely of crystals of carbonate of lime; and which, when its color is white, and texture fine, is the substance used by statuaries.

Seventh, *chlorite schist*, which consists of chlorite, a green or gray substance, somewhat analogous to mica and feldspar.

Eighth, *quartzose rock*, which is composed of quartz in a granular form, sometimes united to small quantities of the crystalline elements, which have been mentioned as belonging to the other rocks.

The secondary rocks are more numerous than the primary; but twelve varieties include all that are usually found in these islands.

First, *grauwacke*, which consists of fragments of quartz, or chlorite schist, embedded in a cement, principally composed of feldspar.

Second, *siliceous sandstone*, which is composed of fine quartz or sand, united by a siliceous cement.

Third. *limestone*, consisting of carbonate of lime, more compact in its texture than in the granular marble; and often abounding in marine exuviæ.

Fourth, *aluminous schist* or *shale*, consisting of the decomposed materials of different rocks cemented by a small quantity of ferruginous or siliceous matter; and often containing the impressions of vegetables.

Fifth, *calcareous sandstone*, which is calcareous sand, cemented by calcareous matter.

Sixth, *ironstone*, formed of nearly the same materials as aluminous schist or shale; but containing a much larger quantity of oxide of iron.

Seventh, *basalt* or *whinstone*, which consists of feldspar and hornblende, with materials derived from the decomposition of the primary rocks; the crystals are generally so small as to give the rock a homogeneous appearance; and it is often disposed in very regular columns, having usually five or six sides.

Eighth, *bituminous* or *common coal*.

Ninth, *gypsum*, the substance so well known by that name, which consists of sulphate of lime; and often contains sand.

Tenth, *rock salt*.

Eleventh, *chalk*, which usually abounds in remains of marine animals, and contains horizontal layers of flints.

Twelfth, *plumb pudding stone*, consisting of pebbles cemented by a ferruginous or siliceous cement.

To describe more particularly the constituent parts of the different rocks and strata will be unnecessary; at any time, indeed, details on this subject are useless, unless the specimens are examined by the eye; and a close inspection and comparison of the different species will in a short time enable the most common observer to distinguish them.

The highest mountains in these islands, and indeed in the whole of the old continent, are constituted by granite; and this rock has likewise been found at the greatest depths to which the industry of man has yet been able to penetrate; micaceous schist is often found immediately upon granite; serpentine or marble upon micaceous schist; but the order in which the primary rocks are grouped together is various. Marble and serpentine are usually found uppermost; but granite, though it seems to form the foundation of the rocky strata of the globe, is yet sometimes discovered above micaceous schist.

The secondary rocks are always incumbent on the primary; the lowest of them is usually grauwacke; upon this limestone or sandstone is often found; coal generally occurs between sandstone or shale; basalt often exists above sandstone and limestone; rock salt almost always occurs associated with red sandstone and gypsum. Coal, basalt, sandstone, and limestone, are often arranged in different alternate layers, of no considerable thickness, so as to form a great extent of country. In a depth of less than 500 yards, 80 of these different alternate strata have been counted.

The veins which afford metallic substances, are fissures vertical or more or less inclined, filled with a material different from the rock in which they exist. This material is almost always crystalline; and usually consists of calcareous fluor spar, quartz, or heavy spar, either separate or together. The metallic substances are generally dispersed through, or confusedly mixed with these crystalline bodies. The veins in hard granite seldom afford much useful metal; but in the veins in soft granite and in gneiss tin, copper, and lead are found. Copper and iron are the only metals usually found in the veins in serpentine. Micaceous schist, sienite, and granular marble are seldom metalliferous rocks. Lead, tin, copper, iron, and many other metals, are found in the veins in chlorite schist. Grauwacke, when it contains few fragments, and exists in large masses, is often a metalliferous rock. The precious metals, likewise iron, lead, and antimony, are found in it: and sometimes it contains veins, or masses of *stone coal*, or coal free from bitumen. Limestone is the great metalliferous rock of the secondary family; and lead and copper are the metals most usually found in it. No metallic veins have ever been found in shale, chalk, or calcareous sandstone; and they are very rare in basalt and siliceous sandstone.*

In cases where veins in rocks are exposed to the atmosphere, indications of the metals they contain may be often gained from their superficial appearance. Whenever fluor spar is found in a vein, there is always strong reason to suspect that it is associated with metallic substances. A brown powder at the surface of a vein always indicates iron, and often tin; a pale yellow powder lead;

* Fig. 16. will give a general idea of the appearance and arrangement of rocks and veins.

Explanation of Figure 16.

1 Granite.—2 Gneiss.—3 Micaceous Schistus.—4 Sienite.—5 Serpentine.—6 Porphyry.—7 Granular Marble.—8 Chlorite Schist.—9 Quartzose Rock.—10 Grauwacke.—11 Siliceous Sandstone.—12 Limestone.—13 Shale.—14 Calcareous Sandstone.—15 Iron Stone.—16 Basalt.—17 Coal.—18 Gypsum.—19 Rock Salt.—20 Chalk.—21 Plum Pudding Stone.—AA Primary Mountains.—BB Secondary Mountains.—*aaa* Veins.

and a green colour in a vein denotes the presence of copper.

It may not be improper to give a general description of the geological constitution of Great Britain and Ireland. Granite forms the great ridge of hills extending from Land's End through Dartmore into Devonshire. The highest rocky strata in Somersetshire are grauwacke and limestone. The Malvern hills are composed of granite, sienite, and porphyry. The highest mountains in Wales are chlorite schist, or grauwacke. Granite occurs at Mount Sorrel, in Leicestershire. The great range of the mountains in Cumberland and Westmoreland are prophyry, chlorite schist, and grauwacke; but granite is found as their western boundary. Throughout Scotland the most elevated rocks are granite, sienite, and micaceous schistus. No true secondary formations are found in South Britain, west of Dartmore; and no basalt south of the Severn. The chalk district extends from the western part of Dorsetshire to the eastern coast of Norfolk. The coal formations abound in the district between Glamorganshire and Derbyshire: and likewise in the secondary strata of Yorkshire. Durham, Westmorland, and Northumberland. Serpentine is found only in three places in Great Britain; near Cape Lizard in Cornwall, Portsoy in Aberdeenshire, and in Ayrshire. Black and gray granular marble is found near Padstow in Cornwall; and other colored primary marbles exist in the neighborhood of Plymouth. Colored primary marbles are abundant in Scotland; and white granular marble is found in the Isle of Sky, in Assynt, and on the banks of Loch Shin in Sutherland: the principal coal formations in Scotland are in Dumbartonshire, Ayrshire, Fifeshire, and on the banks of the Brora, in Sutherland. Secondary limestone and sandstone are found in most of the low countries north of the Mendip hills.

In Ireland there are five great associations of primary mountains; the mountains of Morne, in the county of Down; the mountains of Donegal; those of Mayo and Galway; those of Wicklow; and those of Kerry. The rocks composing the four first of these mountain chains are principally granite, gneiss, sienite, micaceous schist, and porphyry. The mountains of Kerry are chiefly constituted by granular quartz, and chlorite schist. Colored marble is found near Killarney; and white marble on the western coast of Donegal.

Limestone and sandstone are the common secondary rocks found south of Dublin. In Sligo, Roscommon, and Leitrim, limestone, sandstone, shale, ironstone, and bituminous coal are found. The secondary hills in these counties are of considerable elevation; and many of them have basaltic summits. The north coast of Ireland is principally basalt; this rock commonly reposes upon a white limestone, containing layers of flint, and the same fossils as chalk; but it is considerably harder than that rock. There are some instances, in this district, in which columnar basalt is found above sandstone and shale, alternating with coal. The stone-coal of Ireland is principally found in Kilkenny, associated with limestone and grauwacke.

It is evident from what has been said concerning the production of soils from rocks, that there must be at least as many varieties of soils as there are species of rocks exposed at the surface of the earth; in fact there are many more. Independent of the changes produced by cultivation and the exertions of human labor, the materials of strata have been mixed together and transported from place to place by various great alterations that have taken place in the system of our globe, and by the constant operation of water.

To attempt to class soils with scientific accuracy would be a vain labor; the distinctions adopted by farmers are sufficient for the purposes of agriculture; particularly if some degree of precision be adopted in the application of terms. The term sandy, for instance, should never be applied to any soil that does not contain at least $\frac{7}{8}$ of sand; sandy soils that effervesce with acids should be distinguished by the name of calcareous sandy soil, to distinguish them from those that are siliceous. The term clayey soil should not be applied to any land which contains less than $\frac{1}{8}$ of impalpable earthy matter, not considerably effervescing with acids: the word loam should be limited to soils containing at least one-third of impalpable earthy matter, copiously effervescing with acids. A soil, to be considered as peaty, ought to contain at least one-half of vegetable matter.

In cases where the earthy part of a soil evidently consists of a decomposed matter of one particular rock, a name derived from the rock may with propriety be applied to it. Thus, if a fine red earth be found immediately decomposing basalt, it may be denominated basaltic soil. If fragments of quartz and mica be found abundant in the materials of the soil, which is often the case, it may be denominated granitic soil; and the same principles may be applied to other like instances.

In general, the soils, the materials of which are the most various and heterogeneous, are those called alluvial, or which have been formed from the depositions of rivers; many of them are extremely fertile. I have examined some productive alluvial soils, which have been very different in their composition. The soil which has been mentioned before, as very productive, from the banks of the river Parret in Somersetshire, afforded me eight parts of finely divided earthy matter, and one part of siliceous sand; and an analysis of the finely divided matter gave the following results:—

360 parts of carbonate of lime.
25 — alumina.
20 — silica.
8 — oxide of iron.
19 — vegetable, animal, and saline matter.

A rich soil from the neighborhood of the Avon, in the valley of Evesham in Worcestershire, afforded me three-fifths of fine sand, and two-fifths of impalpable matter; the impalpable matter consisted of

35 Alumina.
41 Silica.
14 Carbonate of lime.
3 Oxide of iron.
7 Vegetable, animal, and saline matter.

A specimen of good soil from Tiviotdale, afforded five-sixths of fine siliceous sand, and one-sixth of impalpable matter; which consisted of

41 Alumina.
42 Silica.
4 Carbonate of lime.
5 Oxide of iron.
8 Vegetable, animal, and saline matter.

A soil yielding excellent pasture from the valley of the Avon, near Salisbury, afforded one-eleventh

of coarse siliceous sand; and the finely divided matter consisted of

7 Alumina.
14 Silica.
63 Carbonate of lime.
2 Oxide of iron.
14 Vegetable, animal, and saline matter.

In all these instances the fertility seems to depend upon the state of division, and mixture of the earthy materials and the vegetable and animal matter; and may be easily explained on the principles which I have endeavored to elucidate in the preceding part of this Lecture.

In ascertaining the composition of steril soils with a view to their improvement, any particular ingredient which is the cause of their unproductiveness, should be particularly attended to; if possible, they should be compared with fertile soils in the same neighborhood, and in similar situations, as the difference of the composition may, in many cases, indicate the most proper methods of improvement. If on washing a steril soil it is found to contain the salt of iron, or any acid matter, it may be ameliorated by the application of quick-lime. A soil of good apparent texture from Lincolnshire, was put into my hands by Sir Joseph Banks as remarkable for sterility. On examining it, I found that it contained sulphate of iron; and I offered the obvious remedy of top-dressing with lime, which converts the sulphate into a manure If there be an excess of calcareous matter in the soil, it may be improved by the application of sand, or clay. Soils too abundant in sand are benefited by the use of clay or marl, or vegetable matter. A field belonging to Sir Robert Vaughan at Nannau, Merionethshire, the soil of which was a light sand, was much burnt up in the summer of 1805; I recommended to that gentleman the application of peat as a top-dressing. The experiment was attended with immediate good effects; and Sir Robert has informed me, that the benefit was permanent. A deficiency of vegetable or animal matter must be supplied by manure. An excess of vegetable matter is to be removed by burning, or to be remedied by the application of earthy materials. The improvement of peats, or bogs, or marsh lands, must be preceded by draining; stagnant water being injurious to all the nutritive classes of plants. Soft black peats, when drained, are often made productive by the mere application of sand or clay as a top-dressing. When peats are acid, or contain ferruginous salts, calcareous matter is absolutely necessary in bringing them into cultivation. When they abound in the branches and roots of trees, or when their surface entirely consists of living vegetables, the wood or the vegetables must either be carried off, or be destroyed by burning. In the last case their ashes afford earthy ingredients, fitted to improve the texture of the peat.

The best natural soils are those of which the materials have been derived from different strata; which have been minutely divided by air and water, and are intimately blended together: and in improving soils artificially, the farmer cannot do better than imitate the processes of nature.

The materials necessary for the purpose are seldom far distant: coarse sand is often found immediately on chalk; and beds of sand and gravel are common below clay. The labor of improving the texture or constitution of the soil is repaid by a great permanent advantage; less manure is required, and its fertility insured. And capital laid out in this way secures for ever the productiveness, and consequently the value, of the land.

LECTURE V.

ON THE NATURE AND CONSTITUTION OF THE ATMOSPHERE, AND ITS INFLUENCE ON VEGETABLES. OF THE GERMINATION OF SEEDS. OF THE FUNCTIONS OF PLANTS IN THEIR DIFFERENT STAGES OF GROWTH; WITH A GENERAL VIEW OF THE PROGRESS OF VEGETATION.

The constitution of the atmosphere has been already generally referred to in the preceding Lectures. Water, carbonic acid gas, oxygen, and azote, have been mentioned as the principal substances composing it; but more minute inquiries respecting their nature and agencies are necessary to afford correct views of the uses of the atmosphere in vegetation.

On these inquiries I now propose to enter; the pursuit of them, I hope, will offer some objects of practical use in farming; and present some philosophical illustrations of the manner in which plants are nourished, their organs unfolded, and their functions developed.

If some of the salt called muriate of lime that has been just heated red be exposed to the air, even in the driest and coldest weather, it will increase in weight and become moist; and in a certain time will be converted into a fluid. If put into a retort and heated, it will yield pure water; will gradually recover its pristine state; and, if heated red, its former weight: so that it is evident that the water united to it was derived from the air. And that it existed in the air in an invisible and elastic form, is proved by the circumstance, that if a given quantity of air be exposed to the salt, its volume and weight will diminish, provided the experiment be correctly made.

The quantity of water which exists in air, as vapor, varies with the temperature. In proportion as the weather is hotter, the quantity is greater. At 50° of Fahrenheit air contains about $\frac{1}{50}$ of its volume of vapor; and as the specific gravity of vapor is to that of air nearly as 10 to 15, this is about $\frac{1}{75}$ of its weight.

At 100°, supposing that there is a free communication with water, it contains about $\frac{1}{14}$ parts in volume, or $\frac{1}{21}$ in weight. It is the condensation of vapor by diminution of the temperature of the atmosphere, which is probably the principal cause of the formation of clouds, and of the deposition of dew, mist, snow, or hail.

The power of different substances to absorb aqueous vapor from the atmosphere by cohesive attraction was discussed in the last Lecture. The leaves of living plants appear to act upon the vapor likewise in its elastic form, and to absorb it. Some vegetables increase in weight from this cause, when suspended in the atmosphere and unconnected with the soil; such are the houseleek, and different species of the aloe. In very intense heats, and when the soil is dry, the life of plants seems to be preserved by the absorbent power of their leaves: and it is a beautiful circumstances in the

economy of nature, that aqueous vapor is most abundant in the atmosphere when it is most needed for the purposes of life: and that when other sources of its supply are cut off, this is most copious.

The compound nature of water has been referred to. It may be proper to mention the experimental proofs of its decomposition into, and composition from, oxygen and hydrogen.

If the metal called potassium be exposed in a glass tube to a small quantity of water, it will act upon it with great violence; elastic fluid will be disengaged, which will be found to be hydrogen; and the same effects will be produced upon the potassium, as if it had absorbed a small quantity of oxygen; and the hydrogen disengaged, and the oxygen added to the potassium, are in weight as 2 to 15; and if two in volume of hydrogen, and one in volume of oxygen, which have the weights of 2 and 15, be introduced into a close vessel, and an electrical spark passed through them, they will inflame and condense into 17 parts of pure water.

It is evident from the statements given in the third lecture, that water forms by far the greatest part of the sap of plants; and that this substance, or its elements, enters largely into the constitution of their organs and solid productions.

Water is absolutely necessary to the economy of vegetation in its elastic and fluid state; and it is not devoid of use even in its solid form. Snow and ice are bad conductors of heat; and when the ground is covered with snow, or the surface of the soil or of water is frozen, the roots or bulbs of the plants beneath are protected by the congealed water from the influence of the atmosphere, the temperature of which in northern winters is usually very much below the freezing point; and this water becomes the first nourishment of the plant in early spring. The expansion of water during its congelation, at which time its volume increases one-twelfth, and its contraction of bulk during a thaw, tend to pulverise the soil; to separate its parts from each other, and to make it more permeable to the influence of the air.

If a solution of lime in water be exposed to the air, a pellicle will speedily form upon it, and a solid matter will gradually fall to the bottom of the water, and in a certain time the water will become tasteless; this is owing to the combination of the lime, which was dissolved in the water, with carbonic acid gas which existed in the atmosphere, as may be proved by collecting the film and the solid matter, and igniting them strongly in a little tube of platina or iron; they will give off carbonic acid gas, and will become quick-lime, which, added to the same water, will again bring it to the state of lime-water.

The quantity of carbonic acid gas in the atmosphere is very small. It is not easy to determine it with precision, and it must differ in different situations; but where there is a free circulation of air, it is probably never more than one-five hundredth, nor less than one-eight hundredth of the volume of air. Carbonic acid gas is nearly one-third heavier than the other elastic parts of the atmosphere in their mixed state: hence, at first view, it might be supposed that it would be most abundant in the lower regions of the atmosphere; but unless it has been immediately produced at the surface of the earth in some chemical process, this does not seem to be the case: elastic fluids of different specific gravities have a tendency to equable mixture by a species of attraction, and the different parts of the atmosphere are constantly agitated and blended together by winds or other causes. De Saussure found lime-water precipitated on Mount Blanc, the highest point of land in Europe; and carbonic acid gas has been always found, apparently in due proportion, in the air brought down from great heights in the atmosphere by aërostatic adventurers.

The experimental proofs of the composition of carbonic acid gas are very simple. If 13 grains of well burnt charcoal be inflamed by a burning-glass in 100 cubical inches of oxygen gas, the charcoal will entirely disappear; and, provided the experiment be correctly made, all the oxygen, except a few cubical inches, will be found converted into carbonic acid; and, what is very remarkable, the volume of the gas is not changed. On this last circumstance it is easy to found a correct estimation of the quantity of pure charcoal and oxygen in carbonic acid gas: the weight of 100 cubical inches of carbonic acid gas is to that of 100 cubical inches of oxygen gas, as 47 to 34: so that 47 parts in weight of carbonic acid gas must be composed of 34 parts of oxygen and 13 of charcoal, which correspond with the numbers given in the second lecture.

Carbonic acid is easily decomposed by heating potassium in it; the metal combines with the oxygen, and the charcoal is deposited in the form of a black powder.

The principal consumption of the carbonic acid in the atmosphere, seems to be in affording nourishment to plants; and some of them appear to be supplied with carbon chiefly from this source.

Carbonic acid gas is formed during fermentation, combustion, putrefaction, respiration, and a number of operations taking place upon the surface of the earth; and there is no other process known in nature by which it can be destroyed but by vegetation.

After a given portion of air has been deprived of aqueous vapor and carbonic acid gas, it appears little altered in its properties; it supports combustion and animal life. There are many modes of separating its principal constituents, oxygen, and azote, from each other. A simple one is by burning phosphorus in a confined volume of air: this absorbs the oxygen and leaves the azote; and 100 parts in volume of air, in which phosphorus has been burnt, yield 79 parts of azote; and by mixing this azote with 21 parts of fresh oxygen gas, artificially procured, a substance having the original characters of air is produced. To procure pure oxygen from air, quicksilver may be kept heated in it, at about 600°, till it becomes a red powder: this powder, when ignited, will be restored to the state of quicksilver by giving off oxygen.

Oxygen is necessary to some functions of vegetables, but its great importance in nature is in its relation to the economy of animals. It is absolutely necessary to their life. Atmospheric air taken into the lungs of animals, or passed in solution in water through the gills of fishes, loses oxygen; and for the oxygen lost, about an equal volume of carbonic acid appears.

The effects of azote in vegetation are not distinctly known. As it is found in some of the products of vegetation, it may be absorbed by

certain plants from the atmosphere. It prevents the action of oxygen from being too energetic, and serves as a medium in which the more essential parts of the air act: nor is this circumstance unconformable to the analogy of nature; for the elements most abundant on the solid surface of the globe, are not those which are the most essential to the existence of the living beings belonging to it.

The action of the atmosphere on plants differs at different periods of their growth, and varies with the various stages of the developement and decay of their organs. Some general idea of its influence may have been gained from circumstances already mentioned: I shall now refer to it more particularly, and endeavor to connect it with a general view of the progress of vegetation.

If a healthy seed be moistened and exposed to air at a temperature not below 45°, it soon germinates; it shoots forth a plume which rises upwards, and a radicle which descends.

If the air be confined, it is found that in the process of germination the oxygen, or a part of it, is absorbed. The azote remains unaltered; no carbonic acid is taken away from the air; on the contrary, some is added.

Seeds are incapable of germinating, except when oxygen is present. In the exhausted receiver of the air-pump, in pure azote, in pure carbonic acid, when moistened they swell, but do not vegetate; and if kept in these gases, lose their living powers, and undergo putrefaction.

If a seed be examined before germination, it will be found more or less insipid, at least not sweet; but after germination it is always sweet. Its coagulated mucilage, or starch, is converted into sugar in the process; a substance difficult of solution is changed into one easily soluble; and the sugar carried through the cells or vessels of the cotyledons, is the nourishment of the infant plant. It is easy to understand the nature of the change, by referring to the facts mentioned in the third lecture; and the production of carbonic acid renders probable the idea, that the principal chemical difference between sugar and mucilage depends upon the sugar containing a larger proportion of the elements of water, and upon a slight difference in the proportions of their carbon.

The absorption of oxygen by the seed in germination, has been compared to its absorption in producing the evolution of fœtal life in the egg; but this analogy is only remote. All animals, from the most to the least perfect classes, require a supply of oxygen.* From the moment the heart begins to pulsate till it ceases to beat, the aëration of the blood is constant, and the function of respiration invariable; carbonic acid is given off in the process, but the chemical change produced in the blood is unknown; nor is there any reason to suppose the formation of any substance similar to sugar. In the production of a plant from a seed, some reservoir of nourishment is needed before the root can supply sap; and this reservoir is the cotyledon, in which it is stored up in an insoluble form, and protected, if necessary, during the winter, and rendered soluble by agents which are constantly present on the surface. The change of starch into sugar, connected with the absorption of oxygen, may be rather compared to a process of fermentation than to that of respiration; it is a change effected upon unorganized matter, and can be artificially imitated; and in most of the chemical changes that occur when vegetable compounds are exposed to air, oxygen is absorbed, and carbonic acid formed or evolved.

It is evident, that in all cases of tillage the seeds should be sown so as to be fully exposed to the influence of the air. And one cause of the unproductiveness of cold clayey adhesive soils is, that the seed is coated with matter impermeable to air.

In sandy soils the earth is always sufficiently penetrable by the atmosphere; but in clayey soils there can scarcely be too great a mechanical division of parts in the process of tillage. Any seed not fully supplied with air, always produces a weak and diseased plant.

The process of malting, which has been already referred to, is merely a process in which germination is artificially produced; and in which the starch of the cotyledon is changed into sugar; which sugar is afterwards, by fermentation, converted into spirit.

It is very evident from the chemical principles of germination, that the process of malting should be carried on no further than to produce the sprouting of the radicle, and should be checked as soon as this has made its distinct appearance. If it is pushed to such a degree as to occasion the perfect developement of the radicle and the plume, a considerable quantity of saccharine matter will have been consumed in producing their expansion, and there will be less spirit formed in fermentation, or produced in distillation.

As this circumstance is of some importance, I made in October, 1806, an experiment relating to it. I ascertained by the action of alcohol, the relative proportions of saccharine matter in two equal quantities of the same barley; in one of which the germination had proceeded so far as to occasion a protrusion of the radicle to nearly a-quarter of an inch beyond the grain in most of the specimens, and in the other of which it had been checked before the radicle was a line in length; the quantity of sugar afforded by the last was to that in the first nearly as six to five.

The saccharine matter in the cotyledons at the time of their change into seed-leaves, renders them exceedingly liable to the attacks of insects:

* The impregnated eggs of insects, and even of fishes, do not produce young ones, unless they are supplied with air, that is, unless the fœtus can respire. I have found that the eggs of moths did not produce larvæ when confined in pure carbonic acid; and when they were exposed in common air, the oxygen partly disappeared, and carbonic acid was formed. The fish in the egg or spawn gains its oxygen from the air dissolved in water; and those fishes that spawn in spring and summer in still water, such as the pike, carp, perch, and bream, deposit their eggs upon subaquatic vegetables, the leaves of which, in performing their healthy functions, supply oxygen to the water. The fish that spawn in winter, such as the salmon and trout, seek spots where there is a constant supply of fresh water, as near the sources of streams as possible, and in the most rapid currents, where all stagnation is prevented, and where the water is saturated with air, to which it has been exposed during its deposition from clouds. It is the instinct leading these fish to seek a supply of air for their eggs which carries them from seas or lakes into the mountain country, which induces them to move against the stream, and to endeavor to overleap weirs, mill-dams, and cataracts.

this principle is at once a nourishment of plants and animals, and the greatest ravages are committed upon crops in this first stage of their growth.

The turnip fly, an insect of the colyoptera genus, fixes itself upon the seed-leaves of the turnip at the time that they are beginning to perform their functions; and when the rough leaves of the plume are thrown forth, it is incapable of injuring the plant to any extent.

Several methods have been proposed for destroying the turnip fly, or for preventing it from injuring the crop. It has been proposed to sow radish-seed with the turnip seed, on the idea that the insect is fonder of the seed-leaves of the radish than those of the turnip: it is said that this plan has not been successful, and that the fly feeds indiscriminately on both.

There are several chemical menstrua which render the process of germination much more rapid, when the seeds have been steeped in them. As in these cases the seed-leaves are quickly produced, and more speedily perform their functions, I proposed it as a subject of experiment to examine whether such menstrua might not be useful in raising the turnip more speedily to that state in which it would be secure from the fly; but the result proved that the practice was inadmissible; for seeds so treated, though they germinated much quicker, did not produce healthy plants, and often died soon after sprouting.

I steeped radish-seeds in September, 1807, for 12 hours, in a solution of chlorine, and similar seeds in very diluted nitric acid, in very diluted sulphuric acid, in weak solution of oxysulphate of iron, and some in common water. The seeds in solutions of chlorine and oxysulphate of iron threw out the germ in two days, those in nitric acid in three days, in sulphuric acid in five, and those in water in seven days. But in the cases of premature germination, though the plume was very vigorous for a short time, yet it became at the end of a fortnight weak and sickly; and at that period less vigorous in its growth than the sprouts which had been naturally developed, so that there can be scarcely any useful application of these experiments. Too rapid growth and premature decay seem invariably connected in organized structures; and it is only by following the slow operations of natural causes, that we are capable of making improvements.

There is a number of chemical substances which are very offensive and even deadly to insects, which do not injure, and some of which even assist vegetation. Several of these mixtures have been tried with various success; a mixture of sulphur and lime, which is very destructive to slugs, does not prevent the ravages of the fly on the young turnip crop. His Grace the Duke of Bedford, at my suggestion, was so good as to order the experiment to be tried on a considerable scale at Woburn farm: the mixture of lime and sulphur was strewed over one part of a field sown with turnips; nothing was applied to the other part, but both were attacked nearly in the same manner by the fly.

Mixtures of soot and quick-lime, and urine and quick-lime, will probably be more efficacious. The volatile alkali given off by these mixtures is offensive to insects; and they afford nourishment to the plant. Mr. T. A. Knight* informs me, that he has tried the method by ammoniacal fumes with success; but more extensive trials are necessary to establish its general efficacy. It may, however, be safely adopted; for if it should fail in destroying the fly, it will at least be a useful manure to the land.

After the roots and leaves of the infant plant are formed, the cells and tubes throughout its structure become filled with fluid, which is usually supplied from the soil, and the function of nourishment is performed by the action of its organs upon the external elements. The constituent parts of the air are subservient to this process; but, as it might be expected, they act differently under different circumstances.

When a growing plant, the roots of which are supplied with proper nourishment, is exposed in the presence of solar light to a given quantity of atmospherical air, containing its due proportion of carbonic acid, the carbonic acid after a certain time is destroyed, and a certain quantity of oxygen is found in its place. If new quantities of carbonic acid gas be supplied, the same result occurs; so that carbon is added to plants from the air by the process of vegetation in sunshine; and oxygen is added to the atmosphere.

This circumstance is proved by a number of experiments made by Drs. Priestley, Ingenhousz, and Woodhouse, and M. T. de Saussure; many

* Mr. Knight has been so good as to furnish me with the following note on this subject.

"The experiment which I tried the year before last, and last year, to preserve turnips from the fly, has not been sufficiently often repeated to enable me to speak with any degree of decision; and last year all my turnips succeeded perfectly well. In consequence of your suggestion, when I had the pleasure to meet you some years ago at Holkham, that lime slaked with urine might possibly be found to kill, or drive off, the insects from a turnip crop, I tried that preparation in mixture with three parts of soot, which was put into a small barrel, with gimlet holes round it, to permit a certain quantity of the composition, about four bushels to an acre, to pass out, and to fall into the drills with the turnip seeds. Whether it was by affording highly stimulating food to the plant, or giving some flavor which the flies did not like, I cannot tell; but in the year 1811, the adjoining rows were eaten away, and those to which the composition was applied, as above described, were scarcely at all touched. It is my intention in future to drill my crop in, first, with the composition on the top of the ridge; and then to sow at least a pound of seed, broad-cast, over the whole ground. The expense of this will be very trifling, not more than 2s. per acre; and the horse-hoe will instantly sweep away all the supernumeraries between the rows, should those escape the flies, to which, however, they will be chiefly attracted; because it will always be found that those insects prefer turnips growing in poor to those in rich ground. One advantage seems to be the acceleration given to the growth of the plants, by the highly stimulative effects of the food they instantly receive, as soon as their growth commences, and long before their radicals have reached the dung. The directions above given apply only to turnips sowed upon ridges, with the manure immediately under them; and I am quite certain, that in all soils turnips should be thus cultivated. The close vicinity of the manure, and the consequent short time required to carry the food into the leaf, and return the organizable matter to the roots, are, in my hypothesis, points of vast importance; and the results in practice are correspondent."

of which I have repeated with similar results. The absorption of carbonic acid gas and the production of oxygen are performed by the leaf; and leaves recently separated from the tree effect the change, when confined in portions of air containing carbonic acid; and absorb carbonic acid and produce oxygen, even when immersed in water holding carbonic acid in solution.

The carbonic acid is probably absorbed by the fluids in the cells of the green or parenchymatous part of the leaf; and it is from this part that oxygen gas is produced during the presence of light. M. Sennebier found that the leaf, from which the epidermis was stripped off, continued to produce oxygen when placed in water containing carbonic acid gas, and the globules of air rose from the denuded parenchyma; and it is shown both from the experiments of Sennebier and Woodhouse, that the leaves most abundant in parenchymatous parts produce most oxygen in water impregnated with carbonic acid.

Some few plants* will vegetate in an artificial atmosphere, consisting principally of carbonic acid, and many will grow for some time in air containing from one-half to one-third; but they are not so healthy as when supplied with smaller quantities of this elastic substance.

Plants exposed to light have been found to produce oxygen gas in an elastic medium and in water containing no carbonic acid gas; but in quantities much smaller than when carbonic acid gas was present.

In the dark, no oxygen gas is produced by plants, whatever be the elastic medium to which they are exposed; and no carbonic acid absorbed. In most cases, on the contrary, oxygen gas, if it be present, is absorbed, and carbonic acid gas is produced.

In the changes that take place in the composition of the organized parts it is probable that saccharine compounds are principally formed during the absence of light; gum, woody fibre, oils, and resins, during its presence; and the evolution of carbonic acid gas, or its formation during the night, may be necessary to give greater solubility to certain compounds in the plant. I once suspected that all the carbonic acid gas, produced by plants in the night, or in shade, might be owing to the decay of some part of the leaf, or epidermis; but the recent experiments of Mr. D. Ellis are opposed to this idea; and I found that a perfectly healthy plant of celery, placed in a given portion of air for a few hours only, occasioned a production of carbonic acid gas, and an absorption of oxygen.

Some persons have supposed that plants exposed in the free atmosphere to the vicissitudes of sunshine and shade, light and darkness, consume more oxygen than they produce, and that their permanent agency upon air is similar to that of animals; and this opinion is espoused by the writer on the subject I have just quoted, in his ingenious researches on vegetation. But all experiments brought forwards in favor of this idea, and particularly his experiments, have been made under circumstances unfavorable to accuracy of result. The plants have been confined and supplied with food in an unnatural manner; and the influence of light upon them has been very much diminished by the nature of the media through which it passed. Plants confined in limited portions of atmospheric air soon become diseased; their leaves decay, and by their decomposition they rapidly destroy the oxygen of the air. In some of the early experiments of Dr. Priestley, before he was acquainted with the agency of light upon leaves, air that had supported combustion and respiration, was found purified by the growth of plants when they were exposed in it for successive days and nights; and his experiments are the more unexceptionable, as the plants, in many of them, grew in their natural states; and shoots, or branches from them, only were introduced through water into the confined atmosphere.

I have made some few researches on this subject, and I shall describe their results. On the 12th of July, 1800, I placed a turf four inches square, clothed with grass, principally meadow fox-tail, and white clover, in a porcelain dish, standing in a shallow tray filled with water; I then covered it with a jar of flint glass, containing 380 cubical inches of common air in its natural state. It was exposed in a garden, so as to be liable to the same changes with respect to light as in the common air. On the 20th of July the results were examined. There was an increase of the volume of the gas, amounting to fifteen cubical inches; but the temperature had changed from 64° to 71°; and the pressure of the atmosphere, which on the 12th had been equal to the support of 30.1 inches of mercury, was now equal to that of 30.2. Some of the leaves of the white clover, and of the fox-tail were yellow, and the whole appearance of the grass less healthy than when it was first introduced. A cubical inch of the gas, agitated in lime-water, gave a slight turbidness to the water; and the absorption was not quite $\frac{1}{130}$ of its volume: 100 parts of the residual gas exposed to a solution of green sulphate of iron, impregnated with nitrous gas, a substance which rapidly absorbs oxygen from air, occasioned a diminution to 80 parts; 100 parts of the air of the garden occasioned a diminution to 79 parts.

If the results of this experiment be calculated upon, it will appear that the air had been slightly deteriorated by the action of the grasses. But the weather was unusually cloudy during the progress of the experiment; the plants had not been supplied in a natural manner with carbonic acid gas; and the quantity formed during the night, and by the action of the faded leaves, must have been partly dissolved by the water; and that this was actually the case, I proved by pouring lime-water into the water, when an immediate precipitation was occasioned. The increase of azote I am inclined to attribute to common air disengaged from the water.

The following experiment I consider as conducted under circumstances more analogous to those existing in nature. A turf four inches square, from an irrigated meadow, clothed with common meadow grass, meadow fox-tail grass, and vernal meadow grass, was placed in a porcelain dish, which swam on the surface of water impregnated with carbonic acid gas. A vessel of thin flint glass, of the capacity of 230 cubical inches, having a funnel furnished with a stop-cock inserted in the top, was made to cover the grass; and the apparatus was exposed in an open place;

* I found the Arenaria tenuifolia to produce oxygen in carbonic acid, which was nearly pure.

a small quantity of water was daily supplied to the grass by means of the stop-cock.* Every day likewise a certain quantity of water was removed by a syphon, and water saturated with carbonic acid gas was supplied in its place; so that it may be presumed that a small quantity of carbonic acid gas was constantly present in the receiver. On the 7th of July, 1807, the first day of the experiment, the weather was cloudy in the morning, but fine in the afternoon; the thermometer at 67, the barometer 30.2: towards the evening of this day a slight increase of the gas was perceived: the next three days were bright; but in the morning of the 11th the sky was clouded; a considerable increase of the volume of the gas was now observed: the 12th was cloudy, with gleams of sunshine; there was still an increase, but less than in the bright days: the 13th was bright. About nine o'clock A. M. on the 14th, the receiver was quite full; and considering the original quantity in the jar, it must have been increased by at least 30 cubical inches of elastic fluid: at times during this day globules of gas escaped. At ten on the morning of the 15th, I examined a portion of the gas; it contained less than $\frac{1}{50}$ of carbonic acid gas; 100 parts of it exposed to the impregnated solution left only 75 parts; so that the air was four per cent. purer than the air of the atmosphere.

I shall detail another similar experiment made with equally decisive results. A shoot from a vine, having three healthy leaves belonging to it, attached to its parent tree, was bent so as to be placed under the receiver which had been used in the last experiment; the water confining the common air was kept in the same manner impregnated with carbonic acid gas: the experiment was carried on from August 6th, till August 14th, 1807; during this time, though the weather had been generally clouded, and there had been some rain, the volume of elastic fluid continued to increase. Its quality was examined on the morning of the 15th; it contained $\frac{1}{4\frac{1}{2}}$ of carbonic acid gas, and 100 parts of it afforded 23.5 of oxygen gas.

These facts confirm the popular opinion, that when the leaves of vegetables perform their healthy functions, they tend to purify the atmosphere in the common variations of weather, and changes from light to darkness.

In germination, and at the time of the decay of the leaf, oxygen must be absorbed; but when it is considered how large a part of the surface of the earth is clothed with perennial grasses, and that half of the globe is always exposed to the solar light it appears by far the most probable opinion, that more oxygen is produced than consumed during the process of vegetation; and that it is this circumstance which is the principal cause of the uniformity of the constitution of the atmosphere.

Animals produce no oxygen gas during the exercise of any of their functions, and they are constantly consuming it; but the extent of the animal, compared to that of the vegetable kingdom, is very small; and the quantity of carbonic acid gas produced in respiration, and in various processes of combustion and fermentation, bears a proportion extremely minute to the whole volume of the atmosphere: if every plant during the progress of its life makes a very small addition of oxygen to the air, and occasions a very small consumption of carbonic acid, the effect may be conceived adequate to the wants of nature.

It may occur as an objection to these views, that if the leaves of plants purify the atmosphere, towards the end of autumn, and through the winter, and early spring, the air in our climates must become impure, the oxygen in it diminish, and the carbonic acid gas increase, which is not the case; but there is a very satisfactory answer to this objection. The different parts of the atmosphere are constantly mixed together by winds, which, when they are strong, move at the rate of from 60 to 100 miles in an hour. In our winter, the south-west gales convey air which has been purified by the vast forests and savannahs of South America, and which passing over the ocean, arrives in an uncontaminated state. The storms and tempests which often occur at the beginning, and towards the middle of our winter, and which generally blow from the same quarter of the globe, have a salutary influence. By constant agitation and motion, the equilibrium of the constituent parts of the atmosphere is preserved; it is fitted for the purposes of life; and those events which the superstitious formerly referred to the wrath of Heaven, or the agency of evil spirits, and in which they saw only disorder and confusion, are demonstrated, by science, to be ministrations of Divine Intelligence, and connected with the order and harmony of our system.

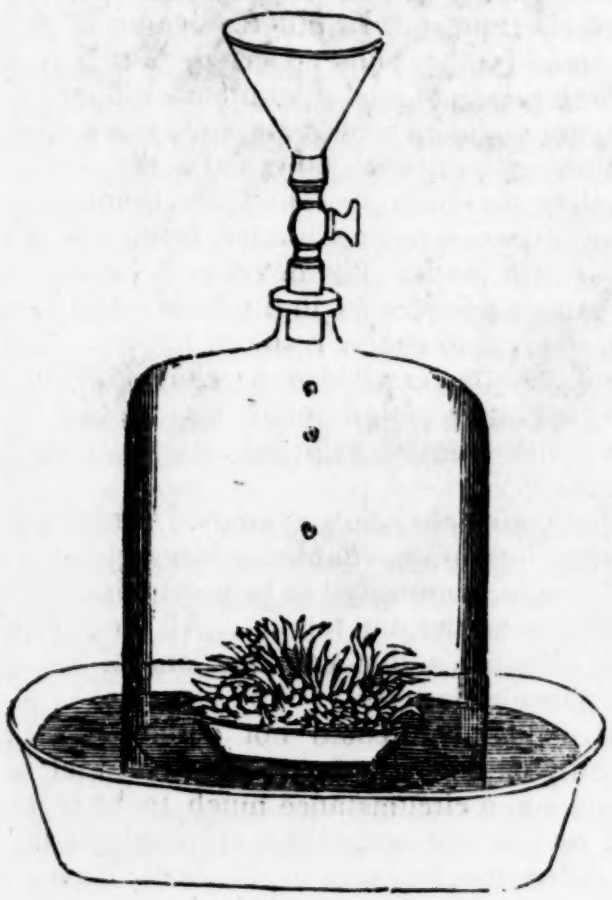
I have reasoned, in a former part of this lecture, against the close analogy which some persons have assumed between the absorption of oxygen and the formation of carbonic acid gas in germination, and in the respiration of the fœtus. Similar arguments will apply against the pursuit of this analogy, between the functions of the leaves of the adult plant, and those of the lungs of the adult animal. Plants grow vigorously only when supplied with light; and most species die if deprived of it. It cannot be supposed that the production of oxygen from the leaf, which is known to be connected with its natural color, is the exertion of a diseased function, or that it can acquire carbon in the day-time, when it is in most vigorous growth, when the sap is rising, when all its powers of obtaining nourishment are exerted, merely for the purpose of giving it off again in the night, when its leaves are closed, when the motion of the sap is imperfect, and when it is in a state approaching to that of quiescence. Many plants that grow upon rocks, or soils, containing no carbonic matter, can only be supposed to acquire their charcoal from the carbonic acid gas in the atmosphere; and the leaf may be considered at the same time as an organ of absorption, and an organ in which the sap may undergo different chemical changes.

When pure water only is absorbed by the roots of plants, the fluid, in passing into the leaves, will probably have greater power to absorb carbonic acid from the atmosphere. When the water is saturated with carbonic acid gas, some of this substance, even in the sunshine, may be given off by the leaves; but a part of it likewise will be always decomposed, which has been proved by the experiments of M. Sennebier.

When the fluid taken up by the roots of plants contains much carbonaceous matter, it is probable that plants may give off carbonic acid from their leaves even in the sunshine. In short, the func-

* See Fig. 17.

Fig. 17.



tion of the leaf must vary according to the composition of the sap passing through it, and according to the nature of the products which are formed from it. When sugar is to be produced, as in early spring at the time of the developement of buds and flowers, it is probable that less oxygen will be given off than at the time of the ripening of the seed, when starch, or gums, or oils, are formed; and the process of ripening the seed usually takes place when the agency of the solar light is most intense. When the acid juices of fruits become saccharine in the natural process of vegetation, more oxygen, there is every reason to believe, must be given off, or newly combined, than at other times; for, as it was shown in the third lecture, all the vegetable acids contain more oxygen than sugar. It appears probable, that in some cases in which oily and resinous bodies are formed in vegetation, water may be decomposed; its oxygen set free, and its hydrogen absorbed.

Mr. Berard, of Montpellier, has shown that fruits in ripening convert the oxygen of the air into carbonic acid; and that the process of ripening may be suspended by the exclusion of the fruit from oxygen gas, and that it will go on again after a certain interval of time. Unripe peaches, plums, and apricots, may be preserved in close bottles, filled with air deprived of oxygen, for from twenty days to a month; and pears and apples about three months, when they will afterward ripen perfectly by exposure to air.

I have already mentioned, that some plants produce oxygen in pure water. Dr. Ingenhousz found this to be the case with species of the conferva. I have tried the leaves of many plants, particularly those that produce volatile oils. When such leaves are exposed in water saturated with oxygen gas, oxygen is given off in the solar light; but the quantity is very small, and always limited; nor have I been able to ascertain with certainty whether the vegetative powers of the leaf were concerned in the operation, though it seems probable. I obtained a considerable quantity of oxygen in an experiment made fifteen years ago, in which vine leaves were exposed to pure water; but on repeating the trials often since, the quantities have always been very much smaller. I am ignorant whether this difference is owing to the peculiar state of the leaves, or to some confervæ which might have adhered to the vessel, or to other sources of fallacy.

The most important and most common products of vegetables, mucilage, starch, sugar, and woody fibre, are composed of water, or the elements of water in their due proportion, and charcoal; and these, or some of them, exist in all plants: and the decomposition of carbonic acid, and the combination of water in vegetable structures, are processes which must occur almost universally.

When glutinous and albuminous substances exist in plants, the azote they contain may be suspected to be derived from the atmosphere: but no experiments have been made which prove this; they might easily be instituted upon mushrooms and funguses.

In cases in which buds are formed, or shoots thrown forth from roots, oxygen appears to be uniformly absorbed, as in the germination of seeds. I exposed a small potato, moistened with common water, to 24 cubical inches of atmospherical air, at a temperature of 59°. It began to throw forth a shoot on the third day; when it was half an inch long I examined the air; nearly a cubical inch of oxygen was absorbed, and about three-fourths of a cubical inch of carbonic acid formed. The juices in a shoot separated from the potato had a sweet taste; and the absorption of oxygen, and the production of carbonic acid, were probably connected with the conversion of a portion of starch into sugar. When potatoes that have been frozen are thawed, they become sweet; probably oxygen is absorbed in this process; if so, the change may be prevented by thawing them out of the contact of air; under water, for instance, that has been recently boiled.

In the tillering of corn, that is, the production of new stalks round the original plume, there is every reason to believe that oxygen must be absorbed; for the stalk at which the tillering takes place always contains sugar, and the shoots arise from a part deprived of light. The drill husbandry favors this process; for loose earth is thrown by hoing round the stalks: they are preserved from light, and yet supplied with oxygen. I have counted from 40 to 120 stalks produced from a grain of wheat, in a moderately good crop of drilled wheat. And we are informed by Sir Kenelm Digby, in 1660, that there was in the possession of the Fathers of the Christian Doctrine at Paris, a plant of barley, which they, at that time, kept by them as a curiosity, and which consisted of 249 stalks springing from one root, or grain; and in which they counted above 18,000 grains or seeds of barley.

The great increase which takes place in the transplantation of wheat depends upon the circumstance, that each layer thrown out in tillering may be removed, and treated as a distinct plant. In the Philosophical Transactions, vol. lviii. page 203, the following statement may be found: Mr. C. Miller, of Cambridge, sowed some wheat on the 2d of June, 1766; and on the 8th of August, a plant was taken and separated into 18 parts, and replanted; these plants were again taken up,

and divided in the months of September and October, and planted separately to stand the winter, which division produced 67 plants. They were again taken up in March and April, and produced 500 plants: the number of ears thus formed from one grain of wheat was 21,109, which gave three pecks and three quarters of corn that weighed 47 lbs. 7 oz., and that were estimated at 576,840 grains.

It is evident from the statements just given, that the change which takes place in the juices of the leaf by the action of the solar light, must tend to increase the proportion of inflammable matter to their other constituent parts. And the leaves of the plants that grow in darkness or in shady places are uniformly pale; their juices are watery and saccharine, and they do not afford oils or resinous substances. I shall detail an experiment on this subject.

I took an equal weight, 400 grains, of the leaves of two plants of endive; one bright green, which had grown fully exposed to light, and the other almost white, which had been secluded from light by being covered with a box; after being both acted upon for some time by boiling water, in the state of pulp, the undissolved matter was dried, and exposed to the action of warm alcohol. The matter from the green leaves gave it a tinge of olive; that from the pale leaves did not alter its color. Scarcely any solid matter was produced by evaporation of the alcohol that had been digested on the pale leaves: whereas, by the evaporation of that from the green leaves a considerable residuum was obtained; five grains of which were separated from the vessel in which the evaporation was carried on; they burnt with flame, and appeared partly matter analogous to resin: 53 grains of woody fibre were obtained from the green leaves, and only 31 from the pale leaves.

It has been mentioned in the third lecture, that the sap probably, in common cases, descends from the leaves into the bark; the bark is usually so loose in its texture, that the atmosphere may possibly act upon it in the cortical layers; but the changes taking place in the leaves appear sufficient to explain the difference between the products obtained from the bark and from the alburnum; the first of which contains more carbonaceous matter than the last.

When the similarity of the elements of different vegetable products is considered according to the views given in the third lecture, it is easy to conceive how the different organized parts may be formed from the same sap, according to the manner in which it is acted on by heat, light, and air. By the abstraction of oxygen, the different inflammable products, fixed and volatile oils, resins, camphor, woody fibre, &c., may be produced from saccharine or mucilaginous fluids; and by the abstraction of carbon and hydrogen, starch, sugar, the different vegetable acids and substances soluble in water, may be formed with highly combustible and insoluble substances. Even the limpid volatile oils which convey the fragrance of the flower, consist of different proportions of the same essential elements as the dense woody fibre; and both are formed by different changes in the same organs, from the same materials, and at the same time.

M. Vauquelin has lately attempted to estimate the chemical changes taking place in vegetation, by analyzing some of the organized parts of the horse-chestnut in their different stages of growth. He found in the buds collected, March 7, 1812, tanning principle, and albuminous matter capable of being obtained separately, but, when obtained, combining with each other. In the scales surrounding the buds, he found the tanning principle, a little saccharine matter, resin, and a fixed oil. In the leaves fully developed, he discovered the same principles as in the buds; and in addition, a peculiar green resinous matter. The petals of the flower yielded a yellowish resin, saccharine matter, albuminous matter, and a little wax: the stamina afforded sugar, resin, and tannin.

The young chestnuts examined immediately after their formation, afforded a large quantity of a matter which appeared to be a combination of albuminous matter and tannin. All the parts of the plant afforded saline combinations of the acetic and phosphoric acids.

M. Vauquelin could not obtain a sufficient quantity of the sap of the horse-chestnut for examination, a circumstance much to be regretted; and he has not stated the relative quantities of the different substances in the buds, leaves, flowers, and seeds. It is probable, however, from his unfinished details, that the quantity of resinous matter is increased in the leaf, and that the white fibrous pulp of the chestnut is formed by the mutual action of albuminous and astringent matter, which probably are supplied by different cells or vessels. I have already mentioned that the cambium, from which the new parts in the trunk and branches appear to be formed, probably owes its power of consolidation to the mixture of two different kinds of sap, one of which flows upwards from the roots, and the other of which probably descends from the leaves. I attempted, in May, 1804, at the time the cambium was forming in the oak, to ascertain the nature of the action of the sap of the alburnum upon the juices of the bark. By perforating the alburnum in a young oak, and applying an exhausting syringe to the aperture, I easily drew out a small quantity of sap. I could not, however, in the same way obtain sap from the bark. I was obliged to recur to the solution of its principles in water, by infusing a small quantity of fresh bark in warm water; the liquid obtained in this way was highly colored and astringent; and produced an immediate precipitate in the alburnous sap, the taste of which was sweetish, and slightly astringent, and which was colorless.

The increase of trees and plants must depend upon the quantity of sap which passes into their organs; upon the quality of this sap; and on its modification by the principles of the atmosphere. Water, as it is the vehicle of the nourishment of the plant, is the substance principally given off by the leaves. Dr. Hales found that a sunflower, in one day of twelve hours, transpired by its leaves one pound fourteen ounces of water, all of which must have been imbibed by its roots.

The powers which cause the ascent of the sap have been slightly touched upon in the second and third lectures. The roots imbibe fluids from the soil by capillary attraction; but this power alone is insufficient to account for the rapid elevation of the sap into the leaves. This is fully proved by the following fact, detailed by Dr.

Hales, vol. i. of the Vegetable Statics, page 114: A vine branch, four or five years old, was cut through, and a glass tube carefully attached to it; this tube was bent as a syphon, and filled with quicksilver; so that the force of the ascending sap could be measured by its effect in elevating the quicksilver. In a few days it was found that the sap had been propelled forwards with so much force as to raise the quicksilver to 38 inches, which is a force considerably superior to that of the usual pressure of the atmosphere. Capillary attraction can only be exerted by the surfaces of small vessels, and can never raise a fluid into tubes above the vessels themselves.

I referred, in the beginning of the third lecture, to Mr. Knight's opinion, that the contractions and expansions of the silver grain in the alburnum are the most efficient cause of the ascent of the fluids contained in its pores and vessels. The views of this excellent physiologist are rendered extremely probable by the facts he has brought forward in support of them. Mr. Knight found that a very small increase of temperature was sufficient to cause the fibres of the silver grain to separate from each other, and that a very slight diminution of heat produced their contraction. The sap rises most vigorously in spring and autumn, at the time the temperature is variable; and if it be supposed that, in expanding and contracting, the elastic fibres of the silver grain exercise a pressure upon the cells and tubes containing the fluid absorbed by the capillary attraction of the roots, this fluid must constantly move upwards towards the points where a supply is needed.

The experiments of Montgolfier, the celebrated inventor of the balloon, have shown that water may be raised almost to an indefinite height by a very small force, provided its pressure be taken off by continued divisions in the column of fluid. This principle, there is great reason to suppose, must operate in assisting the ascent of the sap in the cells and vessels of plants which have no rectilineal communication, and which every where oppose obstacles to the perpendicular pressure of the sap.

The changes taking place in the leaves and buds, and the degree of their power of transpiration, must be intimately connected likewise with the motion of the sap upwards. This is shown by several experiments of Dr. Hales.

A branch from an apple-tree was separated and introduced into water, and connected with a mercurial gauge. When the leaves were upon it, it raised the mercury by the force of the ascending juices to four inches; but a similar branch, from which the leaves were removed, scarcely raised it a quarter of an inch.

Those trees, likewise, whose leaves are soft and of a spongy texture, and porous at their upper surfaces, displayed by far the greatest powers with regard to the elevation of the sap.

The same accurate philosopher whom I have just quoted found that the pear, quince, cherry, walnut, peach, gooseberry, water-elder, and sycamore, which have all soft and unvarnished leaves. raised the mercury under favorable circumstances from three to six inches. Whereas the elm, oak, chestnut, hazel, sallow, and ash, which have firmer and more glossy leaves, raised the mercury only from one to two inches. And the evergreens, and trees bearing varnished leaves, scarcely at all affected it; particularly the laurel and the laurustinus.

It will be proper to mention the facts which show that in many cases fluids descend through the bark. Mr. Knight has shown, in the Philosophical Transactions, that long strips of bark, every where detached from the alburnum of the tree, except at their upper ends, deposited as much alburnum as they could have done, if they had retained their natural position. In these cases, the sap must have descended through the bark wholly.

M. Baisse placed branches of different trees in an infusion of madder, and kept them there for a long time. He found, in all cases, that the wood became red before the bark; and that the bark began to receive no tinge till the whole of the wood was colored, and till the leaves were affected; and that the coloring matter first appeared above, in the bark immediately in contact with the leaves.

Similar experiments were made by M. Bonnet, and with analogous results, though not so perfectly distinct as those of M. Baisse.

Du Hamel found, that in different species of the pine and other trees, when strips of bark were removed, the upper part of the wound only emitted fluid, whilst the lower part remained dry.

This may likewise be observed in the summer in fruit trees, when the bark is wounded, the alburnum remaining untouched.

The motion of the sap through the bark seems principally to depend upon gravitation. When the watery particles have been considerably dissipated by the transpiring functions of the leaves, and the mucilaginous, inflammable, and astringent constituents, increased by the agency of heat, light, and air, the continued impulse upwards from the alburnum forces the remaining inspissated fluid into the cortical vessels, which receive no other supply. In these, from its weight, its natural tendency must be to descend; and the rapidity of the descent must depend upon the general consumption of the fluids of the bark in the living processes of vegetation; for there is every reason to believe that no fluid passes into the soil through the roots; and it is impossible to conceive a free lateral communication between the absorbent vessels of the alburnum in the roots, and the transporting or carrying vessels of the bark; for if such a communication existed, there is no reason why the sap should not rise through the bark as well as through the alburnum; for the same physical powers would then operate upon both.

Some authors have supposed that the sap rises in the alburnum, and descends through the bark, in consequence of a power similar to that which produces the circulation of the blood in animals; a force analogous to the muscular force in the sides of the vessels.

This analogy has, however, in general, been too much insisted upon and too loosely stated; there are undoubtedly resemblances more or less remote in every part of created nature; but the irritability of the muscular fibre in animals and the contractibility of the vascular system in plants appear to depend upon entirely different causes.

In crystallization, or the regular arrangement of inorganic substances, there is a constant increase of matter from the attraction and juxta-position of like parts or molecules. In vegetation a germ ex-

pands by the assimilation of a variety of new aliments, and by powers entirely different from those of common inorganic matter; but there seems to be no system of nerves, as in animals, which is essential to irritability. We know so little of the refined powers and properties of matter, that we can give little more than vague hypotheses as to the cause of the movement of the fluids in the vegetable cells or tubes; yet it is impossible not to allow common material agents a much greater share in producing this phenomenon, than they exercise in animal life.

Whoever will peruse any considerable part of the Vegetable Statics of Hales, must receive a deep impression of the dependence of the motion of the sap upon physical causes. In the same tree, this sagacious person observed that in a cold cloudy morning, when no sap ascended, a sudden change was produced by a gleam of sunshine of half an hour, and a vigorous motion of the fluid. The alteration of the wind from south to the north immediately checked the effect. On the coming on of a cold afternoon after a hot day, the sap that had been rising began to fall. A warm shower and a sleet storm produced opposite effects.

Many of his observations likewise show that the different powers which act on the adult tree, produce different effects at different seasons.

Thus, in the early spring, before the buds expand, the variations of the temperature, and changes of the state of the atmosphere with regard to moisture and dryness, exert their great effects upon the expansions and contractions of the vessels; and then the tree is in what is called by gardeners its bleeding season.

When the leaves are fully expanded, the great determination of the sap is to these new organs. And hence a tree which emits sap copiously from a wound whilst the buds are opening, will no longer emit it in summer when the leaves are perfect; but in the variable weather, towards the end of autumn, when the leaves are falling, it will again possess the power of bleeding in a very slight degree in the warmest days: but at no other times.

In all these circumstances there is nothing truly analogous to the irritable action of animal systems.

In animal systems the heart and arteries are in constant pulsation. Their functions are unceasingly performed in all climates, and in all seasons; in winter, as well as in spring; upon the arctic snows, and under the tropical suns. They neither cease in the periodical nocturnal sleep, common to most animals; nor in the long sleep of winter, peculiar to a few species. The power is connected with animation, is limited to beings possessing the means of voluntary locomotion; it co-exists with the first appearance of vitality; it disappears only with the last spark of life.

As the operation of the different physical agents upon the sap vessels of plants ceases, and the fluid becomes quiescent, the materials dissolved in it by heat are deposited in the cells of the alburnum; and in consequence of this deposition, a nutritive matter is provided for the first wants of the plant in early spring, to assist the opening of the buds, and their expansion, when the motion from the want of leaves is as yet feeble.

This beautiful principle in the vegetable economy was first pointed out by Dr. Darwin; and Mr. Knight has given a number of experimental elucidations of it.

Mr. Knight made numerous incisions into the alburnum of the sycamore and the birch at different heights; and in examining the sap that flowed from them, he found it more sweet and mucilaginous in proportion as the aperture from which it flowed was elevated; which he could ascribe to no other cause than to its having dissolved sugar and mucilage, which had been stored up through the winter.

He examined the alburnum in different poles of oak in the same forest; of which some had been felled in winter, and others in summer; and he always found most soluble matter in the wood felled in winter, and its specific gravity was likewise greater.

In all perennial trees this circumstance takes place; and likewise in grasses and shrubs. The joints of the perennial grasses contain more saccharine and mucilaginous matter in winter than at any other season; and this is the reason why the fiorin or agrostis alba, which abounds in these joints, affords so useful a winter food.

The roots of shrubs contain the largest quantity of nourishing matter in the depth of winter; and the bulb in all plants possessing it is the receptacle in which nourishment is hoarded up during winter.

In annual plants the sap seems to be fully exhausted of all its nutritive matter by the production of flowers and seeds; but if parts of annual plants, having leaves and buds, be detached and kept, so that they do not expend themselves by affording blossoms or seeds, the same individual life may be preserved through many years. It appears, therefore, as Mr. Knight observes, to be habit only, not life, that is annual in such plants.

When perennial grasses are cropped very close by feeding cattle late in autumn, it has been often observed by farmers that they never rise vigorously in the spring; and this is owing to the removal of that part of the stalk which would have afforded them concrete sap, their first nourishment.

Ship-builders prefer for their purposes that kind of oak timber afforded by trees that have had their bark stripped off in spring, and which have been cut in the autumn or winter following. The reason of the superiority of this timber is, that the concrete sap is expended in the spring in the sprouting of the leaf; and the circulation being destroyed, it is not formed anew; and the wood having its pores free from saccharine matter, is less liable to undergo fermentation from the action of moisture and air.

In perennial trees a new alburnum, and consequently a new system of vessels is annually produced, and the nutriment for the next year deposited in them; so that the new buds, like the plume of the seed, are supplied with a reservoir of matter essential to their first developement.

The old alburnum gradually loses its vascular structure, and, being constantly pressed upon by the expansive force of the new fibres, becomes harder, denser, and at length becomes heart-wood; and in a certain time obeys the common laws of dead matter, decays, decomposes, and it is converted into aëriform and carbonic elements; into those principles from which it was originally formed.

The decay of the heart-wood seems to consti-

tute the great limit to the age and size of trees.—And in young branches from old trees, it is much more liable to decompose than in similar branches from seedlings. This is likewise the case with grafts. The graft is only nourished by the sap of the tree to which it is transferred; its properties are not changed by it: the leaves, blossoms, and fruits are of the same kind as if it had vegetated upon its parent stock. The only advantage to be gained in this way, is the affording to a graft from an old tree a more plentiful and healthy food than it could have procured in its natural state; it is rendered for a time more vigorous, and produces fairer blossoms and richer fruits. But it partakes not merely of the obvious properties, but likewise of the infirmities and disposition to old age and decay of the tree whence it sprung.

This seems to be distinctly shown by the observations and experiments of Mr. Knight. He has, in a number of instances, transferred the young scions and healthy shoots from old esteemed fruit-bearing trees to young seedlings. They flourished for two or three years; but they soon became diseased and sickly, like their parent trees.

It is from this cause that so many of the apples formerly celebrated for their taste and their uses in the manufacture of cider are gradually deteriorating, and many will soon disappear. The red streak, and the moil, so excellent in the beginning of the last century, are now in the extremest stage of their decay; and however carefully they are ingrafted, they merely tend to multiply a sickly and exhausted variety.*

The tress possessing the firmest and the least porous heart-wood are the longest in duration.

In general, the quantity of charcoal afforded by woods offers a tolerably accurate indication of their durability: those most abundant in charcoal and earthy matter are most permanent; and those that contain the largest proportion of gaseous elements are the most destructible.

Amongst our own trees, the chestnut and the oak are pre-eminent as to durability; and the chestnut affords rather more carbonaceous matter than the oak.

In old Gothic buildings these woods have been sometimes mistaken one for the other; but they may be easily known by this circumstance, that the pores in the alburnum of the oak are much larger and more thickly set, and are easily distinguished; whilst the pores in the chestnut require glasses to be seen distinctly.

In consequence of the slow decay of the heart-wood of the oak and chestnut, these trees, under favorable circumstances, attain an age which cannot be much short of 1000 years.

The beech, the ash, and the sycamore, most likely never live half as long. The duration of the apple-tree is not, probably, much more than 200 years; but the pear-tree, according to Mr. Knight, lives through double this period. Most of our best apples are supposed to have been introduced into Britain by a fruiterer of Henry the Eighth, and they are now in a state of old age.

The oak and chestnut decay much sooner in a moist situation than in a dry and sandy soil; and their timber is less firm. The sap vessels in such cases are more expanded, though less nourishing matter is carried into them; and the general texture of the formations of wood necessarily less firm. Such wood splits more easily, and is more liable to be affected by variations in the state of the atmosphere.

The same trees, in general, are much longer-lived in the northern than in the southern climates. The reason seems to be, that all fermentation and decomposition are checked by cold; and at very low temperatures both animal and vegetable matters altogether resist putrefaction: and in the northern winter, not only vegetable life, but likewise vegetable decay, must be at a stand.

The anti-putrescent quality of cold climates is fully illustrated in the instances of the rhinoceros and mammoth, lately found in Siberia, entire beneath the frozen soil, in which they must probably have existed from the time of the deluge. I examined a part of the skin of the mammoth sent to this country, on which there was some coarse hair; it had all the chemical characters of recently dried skin.

Trees that grow in situations much exposed to winds, have harder and firmer wood than such as are considerably sheltered. The dense sap is determined by the agitation of the smaller branches to the trunk and larger branches, where the new alburnum formed is consequently thick and firm. Such trees abound in the crooked limbs fitted for forming knee-timber, which is necessary for joining the decks and the sides of ships. The gales in elevated situations gradually act so as to give the tree the form best calculated to resist their effects. And the mountain oak rises robust and sturdy; fixed firmly in the soil, and able to oppose the full force of the tempest.

The decay of the best varieties of fruit-bearing trees which have been distributed through the country by grafts, is a circumstance of great importance. There is no mode of preserving them; and no resource, except that of raising new varieties by seeds.

Where a species has been ameliorated by culture, the seeds it affords, other circumstances being similar, produce more vigorous and perfect plants; and in this way the great improvements in the production of our fields and gardens seem to have been occasioned.

Wheat, in its indigenous state, as a natural production of the soil, appears to have been a very small grass; and the case is still more remarkable with the apple and the plum. The crab seems to have been the parent of all our apples. And two fruits can scarcely be conceived more different, in color, size, and appearance, than the wild plum and the rich magnum bonum.

The seeds of plants exalted by cultivation always furnish large and improved varieties; but the flavor, and even the color of the fruit, seems to be a matter of accident. Thus a hundred seeds

*This opinion relative to the loss of varieties of fruit-bearing trees is not in accordance with the views of M. De Candolle on the subject of the length of life of trees; viz. that, excluding accidents and disease, it is unlimited. Much deference is due to so high an authority; and, assuredly, the doctrine of Mr. Knight, referred to above, should not be received and acted on by practical men, unless clearly demonstrated to be true, because, if taken for granted, it will necessarily lead to the neglect of old varieties of fruit-trees, on the idea that they are in the decline and decrepitude of age, and about to die. *Vide* Physiologie Végétale, liv. 4, chap. xi., where the subject is most ingeniously discussed.—J. D.

of the golden pippin will all produce fine large-leaved apple trees, bearing fruit of a considerable size; but the tastes and colors of the apples from each will be different, and none will be the same in kind as those of the pippin itself. Some will be sweet, some sour, some bitter, some mawkish, some aromatic; some yellow, some green, some red, and some streaked. All the apples will, however, be much more perfect than those from the seeds of a crab, which produce trees all of the same kind, and all bearing sour and diminutive fruit.

The power of the horticulturist extends only to the multiplying excellent varieties by grafting. They cannot be rendered permanent; and the good fruits at present in our gardens are the produce of a few seedlings, selected probably from hundreds of thousands; the results of great labor and industry, and multiplied experiments.

The larger and thicker the leaves of a seedling, and the more expanded its blossoms, the more it is likely to produce a good variety of fruit. Short-leaved trees should never be selected; for these approach nearer to the original standard: whereas the other qualities indicate the influence of cultivation.

In the general selection of seeds, it would appear that those arising from the most highly cultivated varieties of plants, are such as give the most vigorous produce; but it is necessary from time to time to change, and, as it were, to cross the breed.

By applying the pollen, or dust of the stamina, from one variety to the pistil of another of the same species, a new variety may be easily produced; and Mr. Knight's experiments seem to warrant the idea that great advantages may be derived from this method of propagation.

Mr. Knight's large peas, produced by crossing two varieties, are celebrated amongst horticulturists, and will, I hope, soon be cultivated by farmers.

I have seen several of his crossed apples, which promise to rival the best of those which are gradually dying away in the cider countries.

And his experiments on the crossing of wheat, which is very easily effected, merely by sowing the different kinds together, lead to a result which is of considerable importance. He says, in the Philosophical Transactions for 1799, "In the years 1795 and 1796, when almost the whole crop of corn in the island was blighted, the varieties obtained by crossing *alone* escaped, though sown in several soils, and in very different situations."

The processes of gardening for increasing the number of fruit-bearing branches, and for improving the fruit upon particular branches, will all admit of elucidation from the principles that have been advanced in this lecture.

By making trees espaliers, the force of gravity is particularly directed towards the lateral parts of the branches, and more sap determined towards the fruit buds: and hence they are more likely to bear when in a horizontal than when in a vertical position.

The twisting of a wire, or tying a thread round a branch, has been often recommended as a means of making it produce fruit. In this case the descent of the sap in the bark must be impeded above the ligature; and more nutritive matter consequently retained and applied to the expanding parts.

In engrafting, the vessels of the bark of the stock and the graft cannot so perfectly come in contact as the alburnous vessels, which are much more numerous, and equally distributed; hence the circulation downwards is probably impeded, and the tendency of the graft to evolve its fruit-bearing buds increased.

In transplanting trees, if their size is at all considerable, they should be stripped of a portion of their branches and leaves by cutting; for they must in the process of removal from the soil lose a great part of their roots and fine radical fibres; and supposing all their leaves remaining, they would die from exhaustion of their moisture by the great evaporating surface.

By lopping trees more nourishment is supplied to the remaining parts; for the sap flows laterally as well as perpendicularly. The same reasons will apply to explain the increase of the size of fruits by diminishing the number upon a tree.

As plants are capable of amelioration by peculiar methods of cultivation, and of having the natural term of their duration extended; so, in conformity to the general law of change, they are rendered unhealthy by being exposed to peculiarly unfavorable circumstances, and liable to permature old age and decay.

The plants of warm climates transported into cold ones, or of cold ones transported into warm ones, if not absolutely destroyed by the change of situation, are uniformly rendered unhealthy.

Few of the tropical plants, as is well known, can be raised in this country, except in hot houses. The vine during the whole of our summer may be said to be in a feeble state with regard to health; and its fruit, except in very extraordinary cases, always contains a superabundance of acid. The gigantic pine of the north, when transported into the equatorial climates, becomes a degenerated dwarf; and a great number of instances of the same kind might be brought forward.

Much has been written, and many very ingenious remarks have been made by different philosophers, upon what have been called the habits of plants. Thus in transplanting a tree, it dies or becomes unhealthy, unless its position with respect to the sun is the same as before. The seeds brought from warm climates germinate here much more early in the season than the same species brought from cold climates. The apple-tree from Siberia, where the short summer of three months immediately succeeds the long winter, in England, usually puts forth is blossoms in the first year of its transplantation, on the appearance of mild weather; and is often destroyed by the late frosts of the spring.

It is not difficult to explain this principle so intimately connected with the healthy or diseased state of plants. The organization of the germ, whether in seeds or buds, must be different, according as more or less heat or alternations of heat and cold have affected it during its formation; and the nature of its expansion must depend wholly on this organization. In a changeable climate the formations will have been interrupted, and in different successive layers. In an equal temperature they will have been uniform; and the operation of new and sudden causes will of course be severely felt.

The disposition of trees may, however, be changed gradually in many instances; and the operation of a new climate in this way be made supportable. The myrtle, a native of the south of Europe, inevitably dies if exposed in the early state of its growth to the frosts of our winter; but if kept in a green-house during the cold season for successive years, and gradually exposed to low temperatures, it will, in an advanced stage of growth, resist even a very severe cold. And in the south and west of England the myrtle flourishes, produces blossoms and seeds, in consequence of this process, as an unprotected standard tree; and the layers from such trees are much more hardy than the layers from myrtles reared within doors.

The arbutus, probably originally from similar cultivation, has become the principal ornament of the lakes of the south of Ireland. It thrives even in bleak mountain situations; and there can be little doubt but that the offspring of this tree, inured to a temperate climate, might be easily spread in Britain.

The same principles that apply to the effects of heat and cold will likewise apply to the influence of moisture and dryness. The layers of a tree habituated to a moist soil will die in a dry one; even though such a soil is more favorable to the general growth of the species. And, as was already stated, trees that have been raised in the centre of woods are sooner or later destroyed, if exposed in their adult state to blasts, in consequence of the felling of the surrounding timber.

Trees, in all cases in which they are exposed in high and open situations to the sun, the winds, and the rain, as I just now noticed, become low and robust, exhibiting curved limbs, but never straight and graceful trunks. Shrubs and trees, on the contrary, which are too much sheltered, too much secluded from the sun and wind, extend exceedingly in height, but present at the same time slender and feeble branches; their leaves are pale and sickly, and in extreme cases they do not bear fruit. The exclusion of light alone is sufficient to produce this species of disease, as would appear from the experiments of Bonnet. This ingenious physiologist sowed three seeds of the pea in the same kind of soil: one he suffered to remain exposed to the free air; the other he inclosed in a tube of glass; and the third in a tube of wood. The pea in the tube of glass sprouted, and grew in a manner scarcely at all different from that under usual circumstances; but the plant in the tube of wood, deprived of light, became white and slender, and grew to a much greater height.

The plants growing in a soil incapable of supplying them with sufficient manure, or dead organized matter, are very generally low, having brown or dark green leaves; and their woody fibre abounds in earth.* Those vegetating in peaty soils, or in lands too copiously supplied with animal or vegetable matter, rapidly expand, produce large bright green leaves, abound in sap, and generally blossom prematurely.

Where a land is too rich for corn, it is not an uncommon practice to cut down the first stalks, as by these means its exuberance is corrected, and it is less likely to fall before the grain is ripe; excess of poverty, or of richness, is almost equally fatal to the hopes of the farmer; and the true constitution of the soil for the best crop is that in which the earthy materials, the moisture and manure, are properly associated; and in which the decomposable vegetable or animal matter does not exceed one-fourth of the weight of the earthy constituents.

The canker, or erosion of the bark and wood, is a disease produced often in trees by a poverty of soil; and it is invariably connected with old age. The cause seems to be an excess of alkaline and earthy matter in the descending sap. I have often found carbonate of lime on the edges of the canker in apple trees; and ulmin, which contains fixed alkali, is abundant in the canker of the elm. The old age of a tree, in this respect, is faintly analogous to the old age of animals, in which the secretions of solid bony matter are always in excess, and the tendency to ossification great.

The common modes of attempting to cure the canker are by cutting the edges of the bark, binding new bark upon it, or laying on a plaster of earth; but these methods, though they have been much extolled, probably do very little in producing a regeneration of the part. Perhaps the application of a weak acid to the canker might be of use; or where the tree is of great value, it may be watered occasionally with a very diluted acid. The alkaline and earthy nature of the morbid secretion warrants the trial; but circumstances that cannot be foreseen may occur to interfere with the success of the experiment.

Besides the diseases having their source in the constitution of the plant, or in the unfavorable operation of external elements, there are many others perhaps more injurious, depending upon the operations and powers of other living beings; and such are the most difficult to cure, and the most destructive to the labors of the husbandman.

Parasitical plants of different species, which attach themselves to trees and shrubs, feed on their juices, destroy their health, and finally their life, abound in all climates; and are, perhaps, the most formidable of the enemies of the superior and cultivated vegetable species.

The mildew, which has often occasioned great havoc in our wheat crops, and which was particularly destructive in 1804, is a species of fungus, so small as to require glasses to render its form distinct, and rapidly propagated by its seeds.

This has been shown by various botanists; and the subject has received a full illustration from the researches of the late ever to be lamented Sir Joseph Banks.

The fungus rapidly spreads from stalk to stalk, fixes itself in the cells connected with the common tubes, and carries away and consumes that nourishment which should have been appropriated to the grain.

Various remedies have been proposed for this disease. The Rev. Dr. Cartwright states that he

* This is very strikingly illustrated in many of the plants which grow out of the soft free-stone rock of Malta: their growth is stunted; their roots large, branches and leaves small; and their leaves as well as branches abound in lime. From what I have witnessed in that island, I am disposed to believe that plants are instrumental in effecting cavities in calcareous rocks, and that many perforations which have been referred to the operation of boring salt-water mollusca are owing to vegetable growth and decay.—J. D.

has successfully treated it, by the application of a solution of salt, by a common gardening pot, to the stalks of the corn. This is a subject worthy of the most minute investigation; and all methods should be tried which promise to eradicate so great an evil. As the fungus increases by the diffusion of its seeds, great care should be taken that no mildewed straw is carried in the manure used for corn; and in the early crop, if mildew is observed upon any of the stalks of corn, they should be carefully removed, and treated as weeds.

The popular notion amongst farmers, that a barberry-tree in the neighborhood of a field of wheat often produces the mildew, deserves examination. This tree is frequently covered with a fungus, which, if it should be shown to be capable of degenerating into the wheat fungus, would offer an easy explanation of the effect.

There is some reason to believe, from the researches of Sir Joseph Banks, that the smut in wheat likewise is produced by a very small fungus which fixes on the grain; the products that it affords by analysis are similar to those afforded by the puff-ball; and it is difficult to conceive, that without the agency of some organized structure, so complete a change should be effected in the constitution of the grain.

The misletoe and the ivy, the moss and the lichen, in fixing upon trees, uniformly injure their vegetative processes, though in very different degrees. They are supported from the lateral sap-vessels, and deprive the branches above of a part of their nourishment.

The insect tribes are scarcely less injurious than the parasitical plants.

To enumerate all the animal destroyers and tyrants of the vegetable kingdom, would be to give a catalogue of the greater number of the classes in zoology. Every species of plant almost is the peculiar resting-place or dominion of some insect tribe; and from the locust, the caterpillar, and snail, to the minute aphis, a wonderful variety of the inferior insects are nourished, and live by their ravages upon the vegetable world.

I have already referred to the insect which feeds on the seed-leaf of the turnip.

The Hessian fly, still more destructive to wheat, has, in some seasons, threatened the United States with a famine. And the French government, in 1813, issued decrees with a view to occasion the destruction of the larvæ of the grasshopper.

In general, wet weather is most favorable to the propagation of mildew, funguses, rust, and the small parasitical vegetables; dry weather to the increase of the insect tribes. Nature, amidst all her changes, is continually directing her resources towards the production and multiplication of life; and in the wise and grand economy of the whole system, even the agents that appear injurious to the hopes, and destructive to the comforts of man, are, in fact, ultimately connected with a more exalted state of his powers and his condition. His industry is awakened, his activity kept alive, even by the defects of climates and season. By the accidents which interfere with his efforts, he is made to exert his talents, to look farther into futurity, and to consider the vegetable kingdom not as a secure and unalterable inheritance, spontaneously providing for his wants; but as a doubtful and insecure possession, to be preserved only by labor, and extended and perfected by ingenuity.

LECTURE VI.

ON MANURES OF VEGETABLE AND ANIMAL ORIGIN. OF THE MANNER IN WHICH THEY BECOME THE NOURISHMENT OF THE PLANT. OF FERMENTATION AND PUTREFACTION. OF THE DIFFERENT SPECIES OF MANURES OF VEGETABLE ORIGIN; OF THE DIFFERENT SPECIES OF ANIMAL ORIGIN. OF MIXED MANURES. GENERAL PRINCIPLES WITH RESPECT TO THE USE AND APPLICATION OF SUCH MANURES.

That certain vegetable and animal substances introduced into the soil accelerate vegetation and increase the product of crops, is a fact known since the earliest period of agriculture; but the manner in which manures act, the best modes of applying them, their relative value and durability, are still subjects of discussion. In this lecture, I shall endeavor to lay down some settled principles on these objects; they are capable of being materially elucidated by the recent discoveries in chemistry; and I need not dwell on their great importance to farmers.

The pores in the fibres of the roots of plants are so small, that it is with difficulty they can be discovered by the microscope; it is not, therefore, probable that solid substances can pass into them from the soil. I tried an experiment on this subject: some impalpable powdered charcoal, procured by washing gunpowder, and dissipating the sulphur by heat, was placed in a phial containing pure water in which a plant of peppermint was growing; the roots of the plant were pretty generally in contact with the charcoal. The experiment was made in the beginning of May, 1805; the growth of the plant was very vigorous during a fortnight, when it was taken out of the phial: the roots were cut through in different parts; but no carbonaceous matter could be discovered in them, nor were the smallest fibrils blackened by charcoal, though this must have been the case had the charcoal been absorbed in a solid form.

No substance is more necessary to plants than carbonaceous matter; and if this cannot be introduced into the organs of plants except in a state of solution, there is every reason to suppose that other substances less essential will be in the same case.

I found by some experiments made in 1804, that plants introduced into strong fresh solutions of sugar, mucilage, tanning principle, jelly, and other substances, died: but that plants lived in the same solutions after they had fermented. At that time, I supposed that fermentation was necessary to prepare the food of plants; but I have since found that the deleterious effect of the recent vegetable solutions was owing to their being too concentrated; in consequence of which the vegetable organs were probably clogged with solid matter, and the transpiration by the leaves prevented. In the beginning of June, in the next year, I used solutions of the same substances; but so much diluted, that there was only about one-two hundredth part of solid vegetable or animal matter in the solutions. Plants of mint grow luxuriantly in all these solutions; but least so in that of the astringent matter. I watered some spots of grass in a garden with the different solutions separately, and a spot with common wa-

ter: the grass watered with solutions of jelly, sugar, and mucilage, grew most vigorously; and that watered with the solution of the tanning principle grew better than that watered with common water.

I endeavored to ascertain whether soluble vegetable substances passed in an unchanged state into the roots of plants, by comparing the products of the analysis of the roots of some plants of mint which had grown, some in common water, some in a solution of sugar: 120 grains of the roots of the mint which grew in the solution of sugar afforded five grains of pale green extract, which had a sweetish taste, but which slightly coagulated by the action of alcohol: 120 grains of the roots of the mint which had grown in common water yielded three grains and a half of extract, which was of a deep olive color; its taste was sweetish, but more astringent than that of the other extract, and it coagulated more copiously with alcohol.

These results, though not quite decisive, favor the opinion that soluble matters pass unaltered into the roots of plants; and the idea is confirmed by the circumstances that the radical fibres of plants made to grow in infusions of madder are tinged red; and it may be considered as almost proved by the fact, that substances which are even poisonous to vegetables are absorbed by them. I introduced the roots of a primrose into a weak solution of oxide of iron in vinegar, and suffered it to remain in it till the leaves became yellow; the roots were then carefully washed in distilled water, bruised, and boiled in a small quantity of the same fluid: the decoction of them passed through a filter was examined by the test of infusion of nutgalls; the decoction gained a strong tint of purple, which proves that solution of iron had been taken up by the vessels or pores in the roots.

Vegetable and animal substances deposited in the soil, as is shown by universal experience, are consumed during the process of vegetation; and they can only nourish the plant by affording solid matters capable of being dissolved by water, or gaseous substances capable of being absorbed by the fluids in the leaves of vegetables; but such parts of them as are rendered gaseous, and that pass into the atmosphere, must produce a comparatively small effect; for gases soon become diffused through the mass of the surrounding air. The great object in the application of manure should be to make it afford as much soluble matter as possible to the roots of the plant: and that in a slow and gradual manner, so that it may be entirely consumed in forming its sap and organized parts.

Mucilaginous, gelatinous, saccharine, oily and extractive fluids, and solution of carbonic acid and water are substances that in their unchanged states contain almost all the principles necessary for the life of plants; but there are few cases in which they can be applied as manures, in their pure forms; and vegetable manures, in general, contain a great excess of fibrous and insoluble matter, which must undergo chemical changes before they can become the food of plants.

It will be proper to take a scientific view of the nature of these changes; of the causes which occasion them, and which accelerate or retard them; and of the products they afford.

If any fresh vegetable matter which contains sugar, mucilage, starch, or other of the vegetable compounds soluble in water, be moistened and exposed to air, at a temperature from 55° to 80°, oxygen will soon be absorbed, and carbonic acid formed; heat will be produced, and elastic fluids, principally carbonic acid, gaseous oxide of carbon, and hydro-carbonate will be evolved; a dark-colored liquid, of a slightly sour or bitter taste, will likewise be formed; and if the process be suffered to continue for a time sufficiently long, nothing solid will remain, except earthy and saline matter, colored black by charcoal.

The dark-colored fluid formed in the fermentation always contains acetic acid; and when albumen or gluten exists in the vegetable substance, it likewise contains volatile alkali.

In proportion as there is more gluten, albumen, or matters soluble in water, in the vegetable substances exposed to fermentation, so in proportion, all other circumstances being equal, will the process be more rapid. Pure woody fibre alone undergoes a change very slowly; but its texture is broken down, and it is easily resolved into new elements when mixed with substances more liable to change, containing more oxygen and hydrogen. Volatile and fixed oils, resins and wax, are more susceptible of change than woody fibre when exposed to air and water, but much less liable than the other vegetable compounds; and even the most inflammable substances, by the absorption of oxygen, become gradually soluble in water.

Animal matters in general are more liable to decompose than vegetable substances; oxygen is absorbed, and carbonic acid and ammonia formed in the process of their putrefaction. They produce fœtid compound elastic fluids, and likewise azote: they afford dark-colored acid, and oily fluids and leave a residuum of salts and earths mixed with carbonaceous matter.

The principal substances which constitute the different parts of animals, or which are found in their blood, their secretions, or their excrements, are gelatine, fibrine, mucus, fatty or oily matter, albumen, urea, uric acid, and different acid, saline, and earthy matters.

Of these *gelatine* is the substance which when combined with water forms jelly. It in very liable to putrefaction. According to MM. Gay Lussac and Thenard, it is composed of

47·88 of carbon.
27·207—oxygen.
7·914—hydrogen.
16·998—azote.

These proportions cannot be considered as definite, for they do not bear to each other the ratios of any simple multiples of the number representing the elements; the case seems to be the same with other animal compounds: and even in vegetable substances in general, as appears from the statements given in the third lecture, the proportions are far from having the same simple relations as in the binary compounds capable of being made artificially; such as acids, alkalies, oxides, and in salts.

Fibrine constitutes the basis of the muscular fibre of animals, and a similar substance may be obtained from recent fluid blood; by stirring it with a stick the fibrine will adhere to the stick. It is not soluble in water; but by the action of acids, as Mr. Hatchett has shown, it becomes soluble, and analogous to gelatine. It is less dis-

posed to putrefy than gelatine.* According to MM. Gay Lussac and Thenard, 100 parts of fibrine contain

Of carbon - -	53·360
— oxygen - -	19·685
— hydrogen - -	7 021
— azote - -	19·934

Mucus is very analogous to vegetable *gum* in its characters; and as Dr. Bostock has stated, it may be obtained by evaporating saliva. No experiments have been made upon its analysis; but it is probably similar to gum in composition. It is capable of undergoing putrefaction, but less rapidly than fibrine.

Animal fat and *oils* have not been accurately analyzed; but there is great reason to suppose that their composition is analogous to that of similar substances from the vegetable kingdom.

Albumen has been already referred to, and its analysis stated in the third lecture.

Urea may be obtained by the evaporation of human urine till it is of the consistence of a syrup, and the action of alcohol on the crystalline substance which forms when the evaporated matter cools. In this way a solution of urea in alcohol is procured, and the alcohol may be separated from the urea by heat.† Urea is very soluble in water, and is precipitated from water by diluted nitric acid in the form of bright pearl-colored crystals; this property distinguishes it from all other animal substances.

According to Fourcroy and Vauquelin, 100 parts of urea, when distilled, yield

92·027 parts of carbonate of ammonia.
4·608 carburetted hydrogen gas.
3·225 of charcoal.‡

Urea, particularly when mixed with albumen or gelatine, readily undergoes putrefaction.

Uric acid, as has been shown by Dr. Egan, may be obtained from human urine by pouring an acid into it; and it often falls down from urine in the form of brick-colored crystals. It consists of carbon, hydrogen, oxygen, and azote; but their proportions have not yet been determined. Uric acid is one of the animal substances least liable to undergo the process of putrefaction.§

According to the different proportions of these principles in animal compounds, so are the changes they undergo different. When there is much saline or earthy matter mixed or combined with them, the progress of their decomposition is less rapid than when they are principally composed of fibrine, albumen, gelatine, or urea.

The ammonia given off from animal compounds in putrefaction may be conceived to be formed at the time of their decomposition by the combination of hydrogen and azote; except this matter, the other products of putrefaction are analogous to those afforded by the fermentation of vegetable substances; and the soluble substances formed abound in the elements, which are the constituent parts of vegetables, in carbon, hydrogen, and oxygen.

Whenever manures consist principally of matter soluble in water, it is evident that their fermentation or putrefaction should be prevented as much as possible; and the only cases in which these processes can be useful are when the manure consists principally of vegetable or animal fibre. The circumstances necessary for the putrefaction of animal substances are similar to those required for the fermentation of vegetable substances: a temperature above the freezing point; the presence of water, and the presence of oxygen, at least in the first stage of the process.

To prevent manures from decomposing, they should be preserved dry, defended from the contact of air, and kept as cool as possible.

Salt and alcohol appear to owe their powers of preserving animal and vegetable substances to their attraction for water, by which they prevent its decomposing action, and likewise to their excluding air. The use of ice in preserving animal substances is owing to its keeping their temperature low. The efficacy of M. Appert's method of preserving animal and vegetable substances, an account of which has been lately published, entirely depends upon the exclusion of air. This method is by filling a vessel of tin plate or glass with the meat or vegetables; soldering or cementing the top so as to render the vessel air tight; and then keeping it half immersed in a vessel of boiling water for a sufficient time to render the meat or vegetables proper for food. In this last process it is probable that the small quantity of oxygen remaining in the vessel is absorbed; for on opening a tinned iron cannister which had been filled with raw beef, and exposed to hot water the day before, I found that the minute quantity of elastic fluid which could be procured from it, was a mixture of carbonic acid gas and azote.

Where meat or vegetable food is to be preserved on a large scale, for the use of the navy or army, for instance, I am inclined to believe, that by forcibly throwing a quantity of carbonic acid, hydrogen, or azote, into the vessel, by means of a compressing pump, similar to that used for making artificial Seltzer water, any change in the substance would be more effectually prevented. No elastic fluid in this case would have room to form by the decomposition of the meat; and the tightness and strength of the vessel would be proved by the process. No putrefaction or fermentation can go on without the generation of elastic fluid; and pressure would probably act with as much efficacy as cold in the preservation of animal or vegetable food.

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* Fibrine, especially of the blood, according to my experience, putrefies more readily than any other animal substance. In a few hours, at the temperature of 80° Fahrenheit, exposed to the air, by putrefacion it is reduced from a solid to a liquid: the change is accompanied by a considerable disengagement of heat, and formation of ammonia and carbonic acid.—J. D.

† It is best obtained from the nitrate of urea, by means of carbonate of potash and alcohol, according to Dr. Prout's method. Pure urea is colorless, crystallizes in four-sided prisms, and its solution in water resists change for many weeks or even months. It is the only animal compound (or proximate principle) which hitherto has been formed artificially.—J. D.

‡ According to the analysis of Dr. Prout, it consists of

Carbon - - -	12·24
Nitrogen - - -	22·3
Hydrogen - - -	4
Oxygen - - -	16—J. D.

§ It has lately been analysed by Liebig, and found to consist of

Carbon - - -	36·11
Hydrogen - - -	2·34
Nitrogen - - -	33·36
Oxygen - - -	28·10

When pure, it is colorless, tasteless, and without odor.—J. D.

As different manures contain different proportions of the elements necessary to vegetation, so they require a different treatment to enable them to produce their full effects in agriculture. I shall therefore describe in detail the properties and nature of the manures in common use, and give some general views respecting the best modes of preserving and applying them.

All *green succulent plants* contain saccharine or mucilaginous matter, with woody fibre, and readily ferment. They cannot, therefore, if intended for manure, be used too soon after their death.

When *green crops* are to be employed for enriching a soil, they should be ploughed in, if it be possible, when in flower, or at the time the flower is beginning to appear; for it is at this period that they contain the largest quantity of easily soluble matter, and that their leaves are most active in forming nutritive matter. Green crops, pond weeds, the paring of hedges or ditches, or any kind of fresh vegetable matter, require no preparation to fit them for manure. The decomposition slowly proceeds beneath the soil; the soluble matters are gradually dissolved, and the slight fermentation that goes on, checked by the want of a free communication of air, tends to render the woody fibre soluble without occasioning the rapid dissipation of elastic matter.

When old pastures are broken up and made arable, not only has the soil been enriched by the death and slow decay of the plants which have left soluble matters in the soil; but the leaves and roots of the grasses living at the time and occupying so large a part of the surface, afford saccharine, mucilaginous, and extractive matters, which become immediately the food of the crop, and the gradual decomposition affords a supply for successive years.

Rape cake, which is used with great success as a manure, contains a large quantity of mucilage, some albuminous matter, and a small quantity of oil. This manure should be used recent, and kept as dry as possible before it is applied. It forms an excellent dressing for turnip crops; and is most economically applied by being thrown into the soil at the same time with the seed. Whoever wishes to see this practice in its highest degree of perfection, should attend Mr. Coke's annual sheep-shearing at Holkham.

Malt dust consists chiefly of the infant radicle separated from the grain. I have never made any experiment upon this manure; but there is great reason to suppose it must contain saccharine matter; and this will account for it powerful effects. Like rape cake, it should be used as dry as possible, and its fermentation prevented.

Linseed cake is too valuble as a food for cattle to be much employed as a manure; the analysis of linseed was referred to in the third lecture. The *water* in which *flax* and *hemp* are steeped for the purpose of obtaining the pure vegetable fibre, has considerable fertilizing powers. It appears to contain a substance analogous to albumen, and likewise much vegetable extractive matter. It putrefies very readily. A certain degree of fermentation is absolutely necessary to obtain the flax and hemp in a proper state; the water to which they have been exposed should therefore be used as a manure as soon as the vegetable fibre is removed from it.

Sea weeds, consisting of different species of fuci, algæ, and confervæ, are much used as a manure on the sea-coasts of Britain and Ireland. By digesting the common fucus, which is the sea-weed usually most abundant on the coast, in boiling water, I obtained from it one-eighth of a gelatinous substance which had characters similar to mucilage. A quantity distilled gave nearly four-fifths of its weight of water, but no ammonia; the water had an empyreumatic and slightly sour taste; the ashes contained sea salt, carbonate of soda, and carbonaceous matter. The gaseous matter afforded was small in quantity, principally carbonic acid and gaseous oxide of carbon, with a little hydro-carbonate. This manure is transient in this effects, and does not last for more than a single crop, which is easily accounted for from the large quantity of water, or the elements of water, it contains, It decays without producing heat when exposed to the atmosphere, and seems as it were to melt down and dissolve away. I have seen a large heap entirely destroyed in less than two years, nothing remaining but a little black fibrous matter.

I suffered some of the firmest part of a fucus to remain in a close jar containing atmospheric air for a fortnight: in this time it had become very much shrivelled; the sides of the jar were lined with dew. The air examined was found to have lost oxygen, and contained carbonic acid gas.

Sea-weed is sometimes suffered to ferment before it is used; but this process seems wholly unnecessary, for there is no fibrous matter rendered soluble in the process, and a part of the manure is lost.

The best farmers in the west of England use it as fresh as it can be procured; and the practical results of this mode of applying it are exactly conformable to the theory of its operation. The carbonic acid formed by its incipient fermentation must be partly dissolved by the water set free in the same process; and thus become capable of absorption by the roots of plants.

The effects of the sea-weed as manure must principally depend upon this carbonic acid, and upon the soluble mucilage the weed contains; and I found that some fucus which had fermented so as to have lost about half its weight, afforded less than $\frac{1}{13}$ of mucilaginous matter; from which it may be fairly concluded that some of this substance is destroyed in fermentation.

Dry straw of wheat, oats, barley, beans and peas, and spoiled hay, or any other similar kind of dry vegetable matter, is, in all cases, useful manure. In general, such substances are made to ferment before they are employed, though it may be doubted whether the practice should be indiscriminately adopted.

From 400 grains of dry barley straw I obtained eight grains of matter soluble in water, which had a brown color, and tasted like mucilage. From 400 grains of wheaten straw I obtained five grains of a similar substance.

There can be no doubt that the straw of different crops immediately ploughed into the ground affords nourishment to plants; but there is an objection to this method of using straw, from the difficulty of burying long straw, and from its rendering the husbandry foul.

When straw is made to ferment, it becomes a more manageable manure; but there is likewise on the whole a great loss of nutritive matter. More manure is perhaps supplied for a single crop; but

the land is less improved than it would be, supposing the whole of the vegetable matter could be finely divided and mixed with the soil.

It is usual to carry straw that can be employed for no other purpose to the dunghill to ferment and decompose, but it is worth experiment, whether it may not be more economically applied when chopped small by a proper machine, and kept dry till it is ploughed in for the use of a crop. In this case, though it would decompose much more slowly, and produce less effect at first, yet its influence would be much more lasting.

Mere woody fibre seems to be the only vegetable matter that requires fermentation to render it nutritive to plants. Tanners' *spent bark* is a substance of this kind. Mr. Young, in his excellent Essay on Manures, which gained him the Bedfordian medal of the Bath Agricultural Society, states, "that spent bark seemed rather to injure than assist vegetation;" which he attributes to the astrigent matter that it contains. But in fact it is freed from all soluble substances, by the operation of water in the tan-pit; and if injurious to vegetation, the effect is probably owing to its agency upon water, or to its mechanical effects. It is a substance very absorbent and retentive of moisture, and yet not penetrable by the roots of plants.

Inert peaty matter is a substance of the same kind. It remains for years exposed to water and air without undergoing change; and in this state yields little or no nourishment to plants.

Woody fibre will not ferment unless some substances are mixed with it which act the same part as the mucilage, sugar, and extractive or albuminous matters, with which it is usually associated in herbs and succulent vegetables. Lord Meadowbank has judiciously recommended a mixture of common farm-yard dung for the purpose of bringing peas into fermentation; any putrescible or fermentable substance will answer the end; and the more a substance heats, and the more readily it ferments, the better will it be fitted for the purpose.

Lord Meadowbank states, that one part of dung is sufficient to bring three or four parts of peat into a state in which it is fitted to be applied to land; but of course the quantity must vary according to the nature of the dung and of the peat. In cases in which some living vegetables are mixed with the peat, the fermentation will be more readily effected.

Tanners' spent bark, shavings of wood and sawdust, will probably require as much dung to bring them into fermentation, as the worst kind of peat.

Woody fibre may be likewise prepared so as to become a manure by the action of lime. This subject I shall discuss in the next lecture, as it follows naturally another series of facts relating to the effects of lime in the soil.

It is evident from the analysis of woody fibre by MM. Gay Lussac and Thenard, (which shows that it consists principally of the elements of water and carbon, the carbon being in larger quantity than in the other vegetable compounds), that any process which tends to abstract carbonaceous matter from it must bring it nearer in composition to the soluble principles; and this is done in fermentation by the absorption of oxygen and production of carbonic acid; and a similar effect, it will be shown, is produced by lime.

Wood-ashes imperfectly formed, that is, wood-ashes containing much charcoal, are said to have been used with success as a manure. A part of their effects may be owing to the slow and gradual consumption of the charcoal, which seems capable, under other circumstances than those of actual combustion, of absorbing oxygen so as to become carbonic acid.

In April, 1803, I inclosed some well burnt charcoal in a tube half filled with pure water, and half with common air; the tube was hermetically sealed. I opened the tube under pure water in the spring of 1804, at a time when the atmospheric temperature and pressure were nearly the same as at the commencement of the experiment. Some water rushed in; and on expelling a little air by heat from the tube, and analyzing it, it was found to contain only seven per cent. of oxygen. The water in the tube, when mixed with lime-water, produced a copious precipitate; so that carbonic acid had evidently been formed and dissolved by the water.

Manures from animal substances, in general, require no *chemical* preparation to fit them for the soil. The great object of the farmer is to blend them with the earthy constituents in a proper state of division, and to prevent their too rapid decomposition.

The entire parts of the muscles of land animals are not commonly used as a manure, though there are many cases in which such an application might be easily made. Horses, dogs, sheep, deer, and other quadrupeds that have died accidentally, or of disease, after their skins are separated are often suffered to remain exposed to the air, or immersed in water, till they are destroyed by birds or beasts of prey, or entirely decomposed; and in this case most of their organized matter is lost for the land in which they lie, and a considerable portion of it employed in giving off noxious gases to the atmosphere.

By covering dead animals with five or six times their bulk of soil, mixed with one part of lime, and suffering them to remain for a few months, their decomposition would impregnate the soil with soluble matters, so as to render it an excellent manure, and by mixing a little fresh quicklime with it at the time of its removal the disagreeable effluvia would be in a great measure destroyed; and it might be applied in the same way as any other manure to crops.

Fish forms a powerful manure, in whatever state it is applied; but it cannot be ploughed in too fresh, though the quantity should be limited. Mr. Young records an experiment, in which herrings spread over a field and ploughed in for wheat, produced so rank a crop that it was entirely laid before harvest.

The refuse pilchards in Cornwall are used throughout the county as a manure, with excellent effects. They are usually mixed with sand or soil, and sometimes with sea-weed, to prevent them from raising too luxuriant a crop. The effects are perceived for several years.

In the fens of Lincolnshire, Cambridgeshire, and Norfolk, the little fish called sticklebacks, are caught in the shallow waters in such quantities, that they form a great article of manure in the land bordering on the fens.

It is easy to explain the operation of fish as a manure. The skin is principally gelatine; which

from its slight state of cohesion is readily soluble in water: fat or oil is always found in fishes, either under the skin or in some of the viscera; and their fibrous matter contains all the essential elements of vegetable substances.

Amongst oily substances, *blubber* has been employed as manure. It is most useful when mixed with clay, sand, or any common soil, so as to expose a large surface to the air, the oxygen of which produces soluble matter from it. Lord Somerville used blubber with great success at his farm in Surrey. It was made into a heap with soil, and retained its powers of fertilizing for several successive years.

The carbon and hydrogen abounding in oily substances fully account for their effects; and their durability is easily explained from the gradual manner in which they change by the action of air and water.

Bones are much used as a manure in the neighborhood of London. After being broken and boiled for grease, they are sold to the farmer. The more divided they are, the more powerful are their effects. The expense of grinding them in a mill would probably be repaid by the increase of their fertilizing powers; and in the state of powder they might be used in the drill husbandry, and delivered with the seed in the same manner as rape cake.

Bone dust and bone shavings, the refuse of the turning manufacture, may be advantageously employed in the same way.

The basis of bone is constituted by earthy salts, principally phosphate of lime, with some carbonate of lime and phosphate of magnesia; the easily decomposable substances in bone are fat, gelatine, and cartilage, which seem of the same nature as coagulated albumen.

According to the analysis of Fourcroy and Vauquelin, ox bones are composed,

Of decomposable animal matter -	51
— phosphate of lime - - -	37·7
— carbonate of lime - - -	10
— phosphate of magnesia - -	1·3
	100

M. Merat Guillot has given the following estimate of the composition of the bones of different animals:—

	Phosphate of Lime.	Carbonate of Lime.
Bone of Calf . .	54	
— Horse . .	67·5	1·25
— Sheep . .	70	5
— Elk . .	90	1
— Hog . .	52	1
— Hare . .	85	1
— Pullet . .	72	1·5
— Pike . .	64	1
— Carp . .	45	5
Horses' teeth . .	85·5	25
Ivory . .	64	1

The remaining parts of the hundred must be considered as decomposable animal matter.

Horn is a still more powerful manure than bone, as it contains a larger quantity of decomposable animal matter. From 500 grains of ox horn Mr. Hatchett obtained only 1·5 grains of earthy residuum, and not quite half of this was phosphate of lime. The shavings or turnings of horn form an excellent manure, though they are not sufficiently abundant to be in common use. The animal matter in them seems to be of the nature of coagulated albumen, and it is slowly rendered soluble by the action of water. The earthy matter in horn, and still more that in bones, prevents the too rapid decomposition of the animal matter, and renders it very durable in its effects.

Hair, *woollen rags*, and *feathers*, are all analogous in composition, and principally consist of a substance similar to albumen, united to gelatine. This is shown by the ingenious researches of Mr. Hatchett. The theory of their operation is similar to that of bone and horn shavings.

The *refuse* of the different manufactures of *skin* and *leather* form very useful manures; such as the shavings of the currier, furriers' clippings, and the offals of the tan-yard and of the glue-maker. The gelatine contained in every kind of skin is in a state fitted for its gradual solution or decomposition; and when buried in the soil, it lasts for a considerable time, and constantly affords a supply of nutritive matter to the plants in its neighborhood.

Blood contains certain quantities of all the principles found in other animal substances, and is consequently a very good manure. It has been already stated that it contains fibrine; it likewise contains albumen: the red particles in it, which have been supposed by many foreign chemists to be colored by iron in a particular state of combination with oxygen and acid matter, Mr. Brande considers as formed of a peculiar animal substance, containing very little iron.

The scum taken from the boilers of the sugar bakers, and which is used as manure, principally consists of bullock's blood, which has been employed for the purpose of separating the impurities of common brown sugar, by means of the coagulation of its albuminous matter by the heat of the boiler.

The different species of *corals*, *corallines*, and *sponges*, must be considered as substances of animal origin. From the analysis of Mr. Hatchett, it appears that all these substances contain considerable quantities of a matter analogous to coagulated albumen; the sponges afford likewise gelatine.

According to Merat Guillot, white coral contains equal parts of animal matter and carbonate of lime; red coral 46·5 of animal matter, and 53·5 of carbonate of lime; articulated coralline 51 of animal matter, and 49 of carbonate of lime.

These substances are, I believe, never used as manure in this country, except in cases when they are accidentally mixed with sea-weed; but it is probable that the corallines might be advantageously employed, as they are found in considerable quantity on the rocks and bottoms of the rocky pools in many parts of our coast, where the land gradually declines towards the sea; and they might be detached by hoes, and collected without much trouble.

Amongst excrementitious animal substances used as manures, *urine* is the one upon which the greatest number of chemical experiments have been made, and the nature of which is best understood.

The urine of the crow contains, according to the experiments of Mr. Brande,

Of water - - - - -	65
— phosphate of lime - - -	3
— muriates of potassa and ammonia -	15
— sulphate of potassa - - -	6
— carbonates of potassa, and ammonia -	4
— urea - - - - -	4

The urine of the horse, according to Fourcroy and Vauquelin, contains

Of carbonate of lime - - -	11
— carbonate of soda - - -	9
— benzoate of soda - - -	24
— muriate of potassa - - -	9
— urea - - - - -	7
— water and mucilage - - -	940

In addition to these substances, Mr. Brande found in it phosphate of lime.*

The urine of the ass, the camel, the rabbit, and domestic fowls has been submitted to different experiments, and the constitution has been found similar. In the urine of the rabbit, in addition to most of the ingredients above mentioned, Vauquelin detected gelatine; and the same chemist discovered uric acid in the urine of domestic fowls.†

Human urine contains a greater variety of constituents than any other species examined.

Urea, uric acid, and another acid similar to it in nature, called rosacic acid, acetic acid, albumen, gelatine, a resinous matter, and various salts, are found in it.

The human urine differs in composition according to the state of the body, and the nature of the food and drink made use of. In many cases of disease there is a much larger quantity of gelatine and albumen than usual in the urine; and in diabetes it contains sugar.

It is probable that the urine of the same animal must likewise differ according to the different nature of the food and drink used; and this will account for discordances in some of the analyses that have been published on the subject.

Urine is very liable to change and to undergo the putrefactive process; and that of carnivorous animals more rapidly than that of graminivorous animals. In proportion as there is more gelatine and albumen in urine, so in proportion does it putrefy more quickly.

The species of urine that contain most albumen, gelatine, and urea, are the best as manures; and all urine contains the essential elements of vegetables in a state of solution.

During the putrefaction of urine the greatest part of the soluble animal matter that it contains is destroyed; it should consequently be used as fresh as possible; but if not mixed with solid matter, it should be diluted with water, as when pure it contains too large a quantity of animal matter to form a proper fluid nourishment for absorption by the roots of plants.

Putrid urine abounds in ammoniacal salts; and though less active than fresh urine, is a very powerful manure.

According to a recent analysis published by Berzelius, 1000 parts of urine are composed of

Water - - - -	933
Urea - - - -	30.1
Uric acid - - - -	1
Muriate of ammonia, free lactic acid, lactate of ammonia, and animal matter - - - -	17·14

The remainder different salts, phosphates, sulphates, and muriates.

Amongst excrementitious solid substances used as manures, one of the most powerful is the *dung* of *birds* that feed on *animal food*, particularly the dung of sea birds. The *guano*, which is used to a great extent in South America, and which is the manure that fertilizes the steril plains of Peru, is a production of this kind. It exists abundantly, as we are informed by M. Humboldt, on the small islands in the South Sea, at Chinche, Ilo, Iza, and Arica. Fifty vessels are laden with it annually at Chinche, each of which carries from 1500 to 2000 cubical feet. It is used as a manure only in very small quantities; and particularly for crops of maize. I made some experiments on specimens of guano sent from South America to the Board of Agriculture in 1805. It appeared as a fine brown powder; it blackened by heat, and gave off strong ammoniacal fumes: treated with nitric acid, it afforded uric acid. In 1806 MM. Fourcroy and Vauquelin published an elaborate analysis of guano. They state that it contains a fourth part of its weight of uric acid, partly saturated with ammonia, and partly with potassa; some phosphoric acid combined with the same bases, and likewise with lime, small quantities of sulphate and muriate of potassa, a little fatty matter, and some quartzose sand.

It is easy to explain its fertilizing properties: from its composition it might be supposed to be a very powerful manure. It requires water for the solution of its soluble matter, to enable it to produce its full beneficial effect on crops.

The dung of sea birds has, I believe, never been used as a manure in this country: but it is probable that even the soil of the small islands on our coast much frequented by them would fertilize. Some dung of sea birds brought from a rock on the coast of Merionethshire produced a powerful but transient effect on grass. It was tried, at my request, by Sir Robert Vaughan at Nannau.

The rains in our climate must tend very much to injure this species of manure, where it is exposed to them, soon after its deposition; but it may probably be found in great perfection in caverns or clefts in rocks, haunted by cormorants and gulls. I examined some recent cormorant's dung which I found on a rock near Cape Lizard in Cornwall. It had not at all the appearance of the guano; was of a grayish-white color; had a very fœtid smell, like that of putrid animal matter; when acted on by quicklime, it gave abundance of ammonia; treated with nitric acid, it yielded uric acid.

Night-soil, it is well known is a very powerful manure, and very liable to decompose. It differs in its composition; but always abounds in substances composed of carbon, hydrogen, azote, and oxygen. From the analysis of Berzelius, it appears that a part of it is always soluble in water; and in whatever state it is used, whether recent or fermented, it supplies abundance of food to plants.

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* This has not been confirmed by Chevreul. In trials made expressly for the purpose, he was not able to detect phosphate of lime, either in the urine of the horse or of the camel.

† The urine of the mammalia generally abounds most in urea; of birds and reptiles, in uric acid: the urine of the frog and toad, however, are exceptions; their urine is fluid, and not in part solid, like that of birds and reptiles, and contains a large proportion of urea. —J. D.

The disagreeable smell of night-soil may be destroyed by mixing it with quicklime; and if exposed to the atmosphere in thin layers strewed over with quicklime in fine weather, it speedily dries, is easily pulverized, and in this state may be used in the same manner as rape-cake, and delivered into the furrow with the seed.

The Chinese, who have more practical knowledge of the use and application of manures than any other people existing, mix their night-soil with one-third of its weight of a fat marl, make it into cakes, and dry it by exposure to the sun. These cakes, we are informed by the French missionaries, have no disagreeable smell, and form a common article of commerce of the empire.

The earth, by its absorbent powers, probably prevents, to a certain extent, the action of moisture upon the dung, and likewise defends it from the effects of air.

After night-soil, *pigeons' dung* comes next in order, as to fertilizing power. I digested 100 grains of pigeons' dung in hot water for some hours, and obtained from it 23 grains of soluble matter; which afforded abundance of carbonate of ammonia by distillation; and left carbonaceous matter, saline matter principally common salt, and carbonate of lime, as a residuum. Pigeons' dung, when moist, readily ferments, and after fermentation contains less soluble matter than before: from 100 parts of fermented pigeons' dung, I obtained only eight parts of soluble matter, which gave proportionally less carbonate of ammonia in distillation than recent pigeons' dung.

It is evident that this manure should be applied as new as possible; and when dry, it may be employed in the same manner as the other manures capable of being pulverized.

The soil in woods where great flocks of wood-pigeons roost is often highly impregnated with their dung, and, it cannot be doubted, would form a valuable manure. I have found such soil yield ammonia when distilled with lime. In the winter, likewise, it usually contains abundance of vegetable matter, the remains of decayed leaves; and the dung tends to bring the vegetable matter into a state of solution.

The dung of *domestic fowls* approaches very nearly in its nature to pigeons' dung. Uric acid has been found in it. It gives carbonate of ammonia by distillation, and immediately yields soluble matter to water. It is very liable to ferment.

The dung of fowls is employed in common with that of pigeons by tanners to bring on a slight degree of putrefaction in skins that are to be used for making soft leather; for this purpose the dung is diffused through water. In this state, it rapidly undergoes putrefaction, and brings on a similar change in the skin. The excrements of dogs are employed by the tanner with similar effects. In all cases, the contents of the *grainer*, as the pit is called in which soft skins are prepared by dung, must form a very useful manure.

Rabbits' dung has never been analyzed. It is used with great success as a manure by Mr. Fane, who finds it profitable to keep rabbits in such a manner as to preserve their dung. It is laid on as fresh as possible, and is found better the less it has fermented.

The *dung* of *cattle*, *oxen*, and *cows*, has been chemically examined by MM. Einhof and Thaer. They found that it contained matter soluble in water; and that it gave in fermentation nearly the same products as vegetable substances, absorbing oxygen, and producing carbonic acid gas.

The recent *dung* of *sheep* and of *deer*, afford, when long boiled in water, soluble matters, which equal from two to three per cent. of their weight. I have examined these soluble substances procured by solution and evaporation: they contain a very small quantity of matter analogous to animal mucus; and are principally composed of a bitter extract soluble both in water and in alcohol. They give ammoniacal fumes by distillation; and appear to differ very little in composition.

I watered some blades of grass for several successive days with a solution of these extracts; they evidently became greener in consequence, and grew more vigorously than grass in other respects under the same circumstances.

The part of the dung of cattle, sheep and deer, not soluble in water; appears to be mere woody fibre, and precisely analogous to the residuum of those vegetables that form their food after they have been deprived of all their soluble materials.

The dung of horses gives a brown fluid, which, when evaporated, yields a bitter extract, which affords ammoniacal fumes more copiously than that from the dung of oxen.

If the pure dung of cattle is to be used as manure, like the other species of dung which have been mentioned, there seems no reason why it should be made to ferment, except in the soil; or if suffered to ferment, it should be only in a very slight degree. The grass in the neighborhood of recently voided dung is always coarse and dark green; some persons have attributed this to a noxious quality in unfermented dung; but it seems to be rather the result of an excess of food furnished to the plants.

The question of the proper mode of the application of the dung of horses and cattle, however, properly belongs to the subject of *composite manures*, for it is usually mixed in the farm-yard with straw, offal, chaff, and various kinds of litter; and itself contains a large proportion of fibrous vegetable matter.

A slight incipient fermentation is undoubtedly of use in the dunghill; for by means of it a disposition is brought on in the woody fibre to decay and dissolve, when it is carried to the land, or ploughed into the soil; and woody fibre is always in great excess in the refuse of the farm.

Too great degree of fermentation is, however, very prejudicial to the composite manure in the dunghill; it is better that there should be no fermentation at all before the manure is used, than that it should be carried too far. This must be obvious from what has been already stated in this lecture. The excess of fermentation tends to the destruction and dissipation of the most useful part of the manure; and the ultimate results of this process are like those of combustion.

It is a common practice amongst farmers to suffer the farm-yard dung to ferment till the fibrous texture of the vegetable matter is entirely broken down, and till the manure becomes perfectly cold, and so soft as to be easily cut by the spade.

Independent of the general theoretical views unfavorable to this practice founded upon the nature and composition of vegetable substances, there are many arguments and facts which show that it is prejudicial to the interests of the farmer.

During the violent fermentation which is necessary for reducing farm-yard manure to the state in which it is called *short muck*, not only a large quantity of fluid, but likewise of gaseous matter, is lost; so much so, that the dung is reduced one-half, or two-thirds in weight; and the principal elastic matter disengaged is carbonic acid, with some ammonia; and both these, if retained by the moisture in the soil, as has been stated before, are capable of becoming a useful nourishment of plants.

In October, 1808, I filled a large retort, capable of containing three pints of water, with some hot fermenting manure, consisting principally of the litter and dung of cattle; I adapted a small receiver to the retort, and connected the whole with a mercurial pneumatic apparatus, so as to collect the condensible and elastic fluids which might rise from the dung. The receiver soon became lined with dew, and drops began in a few hours to trickle down the sides of it. Elastic fluid likewise was generated; in three days 35 cubical inches had been formed, which, when analyzed, were found to contain 21 cubical inches of carbonic acid; the remainder was hydrocarbonate mixed with some azote, probably no more than existed in the common air in the receiver. The fluid matter collected in the receiver at the same time amounted to nearly half an ounce. It had a saline taste, and a disagreeable smell, and contained some acetate and carbonate of ammonia.

Finding such products given off from fermenting litter, I introduced the beak of another retort, filled with similar dung very hot at the time, into the soil amongst the roots of some grass in the border of a garden; in less than a week a very distinct effect was produced on the grass; upon the spot exposed to the influence of the matter disengaged in fermentation, it grew with much more luxuriance than the grass in any other part of the garden.

Besides the dissipation of gaseous matter when fermentation is pushed to the extreme, there is another disadvantage in the loss of *heat*, which, if excited in the soil, is useful in promoting the germination of the seed, and in assisting the plant in the first stage of its growth, when it is most feeble and most liable to disease: and the fermentation of manure in the soil must be particularly favorable to the wheat crop in preserving a genial temperature beneath the surface late in autumn, and during winter.

Again, it is a general principle in chemistry, that in all cases of decomposition, substances combine much more readily at the moment of their disengagement, than after they have been perfectly formed. And in fermentation beneath the soil, the fluid matter produced is applied instantly, even whilst it is warm, to the organs of the plant, and consequently, is more likely to be efficient than in manure that has gone through the process, and of which all the principles have entered into new combinations.

In the writings of scientific agriculturists, a great mass of facts may be found in favor of the application of farm-yard dung in a recent state. Mr. Young, in the essay on manures, which I have already quoted, adduces a number of excellent authorities in support of the plan. Many who doubted have been lately convinced; and perhaps there is no subject of investigation in which there is such a union of theoretical and practical evidence. I have myself within the last ten years witnessed a number of distinct proofs on the subject. I shall content myself with quoting that which ought to have, and which I am sure will have, the greatest weight among agriculturists. Within the last seven years, Mr. Coke has entirely given up the system formerly adopted on his farm, of applying fermented dung; and he informs me that his crops have been since as good as they ever were, and that his manure goes nearly twice as far.

A great objection against slightly fermented dung, is, that weeds spring up more luxuriantly where it is applied. If there are seeds carried out in the dung, they certainly will germinate; but it is seldom that this can be the case to any extent; and if the land is not cleansed of weeds, any kind of manure fermented or unfermented will occasion their rapid growth. If slightly fermented farm-yard dung is used as a top-dressing for pastures, the long straws and unfermented vegetable matter remaining on the surface should be removed as soon as the grass begins to rise vigorously by raking, and carried back to the dunghill: in this case no manure will be lost, and the husbandry will be at once clean and economical.

In cases when farm-yard dung cannot be immediately applied to crops, the destructive fermentation of it should be prevented as much as possible: the principles on which this may be effected have been already alluded to.

The surface should be defended as much as possible from the oxygen of the atmosphere; a compact marl, or a tenacious clay, offers the best protection against the air; and before the dung is covered over, or, as it were, sealed up, it should be dried as much as possible. If the dung is found at any time to heat strongly, it should be turned over, and cooled by exposure to air.

Watering dunghills is sometimes recommended for checking the progress of fermentation; but this practice is inconsistent with just chemical views. It may cool the dung for a short time; but moisture, as I have before stated, is a principal agent in all processes of decomposition. Dry fibrous matter will never ferment. Water is as necessary as air to the process; and to supply it to fermenting dung, is to supply an agent which will hasten its decay.

In all cases when dung is fermenting, there are simple tests by which the rapidity of the process, and consequently the injury done, may be discovered.

If a thermometer plunged into the dung does not rise to above 100 degrees of Fahrenheit, there is little danger of much aëriform matter flying off. If the temperature is higher, the dung should be immediately spread abroad.

When a piece of paper, moistened in muriatic acid, held over the steams arising from a dunghill, gives dense fumes, it is a certain test that the decomposition is going too far; for this indicates that volatile alkali is disengaged.

When dung is to be preserved for any time, the situation in which it is kept is of importance. It should, if possible, be defended from the sun. To preserve it under sheds would be of great use; or to make the site of a dunghill on the north side of a wall. The floor on which the dung is heaped should, if possible, be paved with flat stones; and

there should be a little inclination from each side towards the centre, in which there should be drains connected with a small well, furnished with a pump, by which any fluid matter may be collected for the use of the land. It too often happens that a dense mucilaginous and extractive fluid is suffered to drain away from the dunghill, so as to be entirely lost to the farm.*

Street and *road dung*, and the *sweepings of houses*, may be all regarded as composite manures; the constitution of them is necessarily various, as they are derived from a number of different substances. These manures are usually applied in a proper manner, without being fermented.

Soot, which is principally formed from the combustion of pit-coal or coal, generally contains likewise substances derived from animal matters. This is a very powerful manure. It affords ammoniacal salts by distillation, and yields a brown extract to hot water, of a bitter taste. It likewise contains an empyreumatic oil. Its basis is charcoal, in a state in which it is capable of being rendered soluble by the action of oxygen and water.

This manure is well fitted to be used in the dry state, thrown into the ground with the seed, and requires no preparation.

The doctrine of the proper application of manures from organized substances offers an illustration of an important part of the economy of nature, and of the happy order in which it is arranged.

The death and decay of animal substances tend to resolve organized forms into chemical constituents; and the pernicious effluvia disengaged in the process seem to point out the propriety of burying them in the soil, where they are fitted to become the food of vegetables. The fermentation and putrefaction of organized substances in the free atmosphere are noxious processes; beneath the surface of the ground, they are salutary operations. In this case the food of plants is prepared where it can be used; and that which would offend the senses and injure the health, if exposed, is converted by gradual processes into forms of beauty and of usefulness; the fœtid gas is rendered a constituent of the aroma of the flower, and what might be poison becomes nourishment to animals and to man.

LECTURE VII.

ON MANURES OF MINERAL ORIGIN, OR FOSSIL MANURES; THEIR PREPARATION, AND THE MANNER IN WHICH THEY ACT. OF LIME IN ITS DIFFERENT STATES; OPERATION OF LIME AS A MANURE AND A CEMENT; DIFFERENT COMBINATIONS OF LIME. OF GYPSUM; IDEAS RESPECTING ITS USE. OF OTHER NEUTRO-SALINE COMPOUNDS, EMPLOYED AS MANURES. OF ALKALIES AND ALKALINE SALTS; OF COMMON SALT.

The whole tenor of the preceding lectures shows that a great variety of substances contributes to the growth of plants, and supplies the materials of their nourishment. The conversion of matter that has belonged to living structures into organized forms is a process than can be easily understood; but it is more difficult to follow those operations by which earthy and saline matters are consolidated in the fibre of plants, and by which they are made subservient to their functions. Some inquirers, adopting that sublime generalization of the ancient philosophers that matter is the same in essence, and that the different substances considered as elements by chemists are merely different arrangements of the same indestructible particles, have endeavored to prove that all the varieties of the principles found in plants may be formed from the substances in the atmosphere; and that vegetable life is a process in which bodies that the analytical philosopher is unable to change or to form are constantly composed and decomposed. These opinions have not been advanced merely as hypotheses; attempts have been made to support them by experiments. M. Schrader and Mr. Braconnot, from a series of distinct investigations, have arrived at the same conclusions. They state that different seeds sown in fine sand, sulphur, and metallic oxides, and supplied only with atmospherical air and water, produced healthy plants, which by analysis yielded various earthy and saline matters, which either were not contained in the seeds or the material in which they grew, or which were contained only in much smaller quantities in the seeds: and hence they conclude that they must have been formed from air or water, in consequence of the agencies of the living organs of the plant.

The researches of these two gentlemen were conducted with much ingenuity and address; but there were circumstances which interfered with their results, which they could not have known, as at the time their labors were published they had not been investigated.

I have found that common distilled water is far from being free from saline impregnations. In analyzing it by Voltaic electricity, I procured from it alkalies and earths; and many of the combinations of metals with chlorine are extremely volatile substances. When distilled water is supplied in an unlimited manner to plants, it may furnish to them a number of different substances, which, though in quantities scarcely perceptible in the water, may accumulate in the plant, which probably perspires only absolutely pure water.

In 1801 I made an experiment on the growth of oats, supplied with a limited quantity of distilled water in a soil composed of pure carbonate of lime. The soil and the water were placed in a vessel of iron, which was included in a large jar, connected with the free atmosphere by a tube, so curved as to prevent the possibility of any dust, or fluid, or solid matter from entering into the jar. My object was to ascertain whether any siliceous earth

* The state in which farm-yard manure should be used is still a *questio vexata*; and is likely to remain so, till an extensive series of judicious experiments shall have been made on the subject by competent persons, equally qualified by theoretical and practical knowledge to arrive at precise results, and to be able to communicate them. The question, in all its relations, is necessarily one of extreme difficulty, as well as of importance. Probably composts, or mixtures of stable and farm-yard manure, with marl, clay, or lime, according to circumstances, will prove most advantageous of all, if kept well covered with earth, so as to allow of a certain degree of fermentation, and yet prevent any material loss of gaseous matter.—J. D.

would be formed in the process of vegetation; but the oats grew very feebly, and began to be yellow before any flowers formed: the entire plants were burnt, and their ashes compared with those from an equal number of grains of oat. Less siliceous earth was given by the plants than by the grains; but their ashes yielded much more carbonate of lime. That there was less siliceous earth, I attribute to the circumstance of the husk of the oat being thrown off in germination; and this is the part which most abounds in silica. Healthy green oats, taken from a growing crop, in a field of which the soil was a fine sand, yielded siliceous earth in a much greater proportion than an equal weight of the corn artificially raised.

The general results of this experiment are very much opposed to the idea of the composition of the earths, by plants, from any of the elements found in the atmosphere, or in water; and there are other facts contradictory to the idea. Jacquin states that the ashes of glass wort (*salsola soda,*) when it grows in inland situations, afford the vegetable alkali; when it grows on the sea-shore, where compounds which afford the fossil or marine alkali are more abundant, it yields that substance. Du Hamel found that plants which usually grow on the sea-shore, made small progress when planted in soils containing little common salt. The sun-flower, when growing in lands containing no nitre, does not afford that substance; though when watered by a solution of nitre, it yields nitre abundantly. The tables of De Saussure, referred to in the third lecture, show that the ashes of plants are similar in constitution to the soils in which they have vegetated.

De Saussure made plants grow in solutions of different salts, and he ascertained that in all cases certain portions of the salts were absorbed by the plant, and found unaltered in their organs.

Even animals do not appear to possess the power of forming the alkaline and earthy substances. Dr. Fordyce found, that when canary birds, at the time they were laying eggs, were deprived of access to carbonate of lime, their eggs had soft shells; and if there is any process for which nature may be conceived most likely to supply resources of this kind, it is that connected with the reproduction of the species.

As the evidence on the subject now stands, it seems fair to conclude, that the different earths and saline substances found in the organs of plants are supplied by the soils in which they grow; and in no cases composed by new arrangements of the elements in air or water. What may be our ultimate view of the laws of chemistry, or how far our ideas of elementary principles may be simplified, it is impossible to say. We can only reason from facts. We cannot imitate the powers of composition belonging to vegetable structures; but at least we can understand them: and, as far as our researches have gone, it appears that in vegetation compound forms are uniformly produced from simpler ones; and the elements in the soil, the atmosphere, and the earth, absorbed and made parts of beautiful and diversified structures.

The views which have been just developed lead to correct ideas of the operation of these manures, which are not necessarily the result of decayed organized bodies, and which are not composed of different proportions of carbon, hydrogen, oxygen, and azote. They must produce their effect, either by becoming a constituent part of the plant, or by acting upon its more essential food, so as to render it more fitted for the purposes of vegetable life.

The only substances which can with propriety be called fossil manures, and which are found unmixed with the remains of any organized beings, are certain alkaline earths, or alkalies, and their combinations.

The only alkaline earths which have been hitherto applied in this way, are lime and magnesia. Potassa and soda, the two fixed alkalies, are both used in certain of their chemical compounds. I shall state in succession such facts as have come to my knowledge respecting each of these bodies in their applications to the purposes of agriculture; but I shall enlarge most upon the subject of lime; and if I should enter into some details which may be tedious and minute, I trust, my excuse will be found in the importance of the inquiry; and it is one which has been greatly elucidated by late discoveries.

The most common form in which lime is found on the surface of the earth, is in a state of combination with carbonic acid or fixed air. If a piece of limestone, or chalk, be thrown into a fluid acid, there will be an effervescence. This is owing to the escape of the carbonic acid gas. The lime becomes dissolved in the liquor.

When limestone is strongly heated, the carbonic acid gas is expelled, and then nothing remains but the pure alkali earth: in this case there is a loss of weight; and if the fire has been very high, it approaches to one-half the weight of the stone; but in common cases, limestones, if well dried before burning, do not lose much more than from 30 to 40 per cent., or from seven to eight parts out of 20.

I mentioned, in discussing the agencies of the atmosphere upon vegetables, in the beginning of the fifth lecture, that air always contains carbonic acid gas, and that lime is precipitated from water by this substance. When burnt lime is exposed to the atmosphere, in a certain time it becomes mild, and is the same substance as that precipitated from lime-water; it is combined with carbonic acid gas. Quicklime, when first made, is caustic and burning to the tongue, renders vegetable blues green, and is soluble in water; but when combined with carbonic acid it loses all these properties, its solubility, and its taste: it regains its power of effervescing, and becomes the same chemical substance as chalk or limestone.

Very few limestones or chalks consist entirely of lime and carbonic acid. The statuary marbles or certain of the rhomboidal spars, are almost the only pure species; and the different properties of limestones, both as manures and cements, depend upon the nature of the ingredients mixed in the limestone; for the true calcareous element, the carbonate of lime, is uniformly the same in nature, properties, and effects, and consists of one proportion of carbonic acid 41·4, and one of lime 55.

When a limestone does not copiously effervesce in acids, and is sufficiently hard to scratch glass, it contains siliceous, and probably aluminous earth. When it is deep brown or red, or strongly colored of any of the shades of brown or yellow, it contains oxide of iron. When it is not sufficiently hard to scratch glass, but effervesces slowly, and makes the acid in which it effervesces milky, it contains magnesia. And when it is black and

emits a fœtid smell if rubbed, it contains coally or bituminous matter.

The analysis of limestones is not a difficult matter; and the proportions of their constituent parts may be easily ascertained by the process described in the lecture on the analysis of soils; and usually with sufficient accuracy for all the purposes of the farmer, by the fifth process.

Before any opinion can be formed of the manner in which the different ingredients in limestones modify their properties, it will be necessary to consider the operation of the pure calcareous element as a manure, and as a cement.

Quicklime in its pure state, whether in powder or dissolved in water, is injurious to plants. I have in several instances killed grass by watering it with lime-water. But lime, in its state of combination with carbonic acid, as is evident from the analysis given in the fourth lecture, is a useful ingredient in soils. Calcareous earth is found in the ashes of the greater number of plants; and exposed to the air lime cannot long continue caustic, for the reasons that were just now assigned, but soon becomes united to carbonic acid.

When newly burnt lime is exposed to air, it soon falls into powder; in this case it is called slacked-lime; and the same effect is immediately produced by throwing water upon it, when it heats violently, and the water dissappears.

Slacked-lime is merely a combination of lime with about one-third of its weight of water; *i. e.* 55 parts of lime absorb 17 parts of water; and in this case it is composed of a definite proportion of lime to a definite proportion of water, and is called by chemists *hydrate of lime;* and when hydrate of lime becomes carbonate of lime by long exposure to air, the water is expelled, and the carbonic acid gas takes its place.

When lime, whether freshly burnt or slacked, is mixed with any moist fibrous vegetable matter, there is a strong action between the lime and the vegetable matter, and they form a kind of compost together, of which a part is usually soluble in water.

By this kind of operation, lime renders matter which was before comparatively inert nutritive; and as charcoal and oxygen abound in all vegetable matters, it becomes at the same time converted into carbonate of lime.

Mild lime, powdered limestone, marls or chalks, have no action of this kind upon vegetable matter; by their action they prevent the too rapid decomposition of substances already dissolved; but they have no tendency to form soluble matters.

It is obvious from these circumstances, that the operation of quicklime, and marl or chalk, depends upon principles altogether different. Quicklime, in being applied to land, tends to bring any hard vegetable matter that it contains into a state of more rapid decomposition and solution, so as to render it a proper food for plants. Chalk, and marl, or carbonate of lime, will only improve the texture of the soil, or its relation to absorption: it acts merely as one of its earthy ingredients. Quicklime, when it becomes mild, operates in the same manner as chalk; but in the act of becoming mild, it prepares soluble out of insoluble matter.

It is upon this circumstance that the operation of lime in the preparation for wheat crops depends; and its efficacy in fertilizing peats, and in bringing into a state of cultivation all soils abounding in hard roots, or dry fibres, or inert vegetable matter.

The solution of the question, whether quicklime ought to be applied to a soil, depends upon the quantity of inert vegetable matter that it contains. The solution of the question, whether marl, mild lime, or powdered limestone, ought to be applied, depends upon the quantity of calcareous matter already in the soil. All soils are improved by mild lime, and ultimately by quicklime, which do not effervesce with acids; and sands more than clays.

When a soil, deficient in calcareous matter, contains much *soluble* vegetable manure, the application of quicklime should always be avoided, as it either tends to decompose the soluble matters by uniting to their carbon and oxygen so as to become mild lime, or it combines with the soluble matters, and forms compounds, having less attraction for water than the pure vegetable substance.

The case is the same with respect to most animal manures; but the operation of the lime is different in different cases, and depends upon the nature of the animal matter. Lime forms a kind of insoluble soap with oily matters, and then gradually decomposes them by separating from them oxygen and carbon. It combines likewise with the animal acids; and probably assists their decomposition by abstracting carbonaceous matter from them combined with oxygen: and consequently it must render them less nutritive. It tends to diminish likewise the nutritive powers of albumen from the same causes; and always destroys to a certain extent the efficacy of animal manures, either by combining with certain of their elements, or by giving to them new arrangements. Lime should never be applied with animal manures, unless they are too rich, or for the purpose of preventing noxious effluvia, as in certain cases mentioned in the last lecture. It is injurious when mixed with any common dung, and tends to render the extractive matter insoluble.

I made an experiment on this subject: I mixed a quantity of the brown soluble extract, which was procured from sheep's dung, with five times its weight of quicklime. I then moistened them with water; the mixture heated very much; it was suffered to remain for 14 hours, and was then acted on by six or seven times its bulk of pure water: the water, after being passed through a filter, was evaporated to dryness; the solid matter obtained was scarcely colored, and was lime mixed with a little saline matter.

In those cases in which fermentation is useful to produce nutriment from vegetable substances, lime is always efficacious. I mixed some moist tanners' spent bark with one-fifth of its weight of quicklime, and suffered them to remain together in a close vessel for three months; the lime had become colored, and was effervescent: when water was boiled upon the mixture, it gained a tint of fawn-color, and by evaporation furnished a fawn-colored powder, which must have consisted of lime united to vegetable matter, for it burnt when strongly heated, and left a residuum of mild lime.*

* The manner in which lime acts in agriculture requires further and minute investigation, and is a most important subject for inquiry. From the experiments

The limestones containing alumina and silica are less fitted for the purposes of manure than pure limestones; but the lime formed from them has no noxious quality. Such stones are less efficacious, merely because they furnish a smaller quantity of quicklime.

I mentioned bituminous limestones. There is very seldom any considerable portion of coally matter in these stones; never as much as five parts in 100; but such limestones make very good lime. The carbonaceous matter can do no injury to the land, and may, under certain circumstances, become a food of the plant, as is evident from what was stated in the last lecture.

The subject of the application of the magnesian limestone is one of great interest.

It had been long known to farmers in the neighborhood of Doncaster, that lime made from a certain limestone applied to the land often injured the crops considerably, as I mentioned in the introductory lecture. Mr. Tennant, in making a series of experiments upon this peculiar calcareous substance, found that it contained magnesia; and on mixing some calcined magnesia with soil in which he sowed different seeds, he found that they either died, or vegetated in a very imperfect manner, and the plants were never healthy. And with great justice and ingenuity he referred the bad effects of the peculiar limestone to the magnesian earth it contains.

In making some inquiries concerning this subject, I found that there were cases in which this magnesian limestone was used with good effect.

Amongst some specimens of limestone which Lord Somerville put into my hands, two marked as peculiarly good proved to be magnesian limestones. And lime made from the Breedon limestone is used in Leicestershire, where it is called hot lime; and I have been informed by farmers in the neighborhood of the quarry, that they employ it advantageously in small quantities, seldom more than 25 or 30 bushels to the acre. And that they find it may be used with good effect in larger quantities upon rich land.

A minute chemical consideration of this question will lead to its solution.

Magnesia has a much weaker attraction for carbonic acid than lime, and will remain in the state of caustic or calcined magnesia for many months, though exposed to the air. And as long as any caustic lime remains, the magnesia cannot be combined with carbonic acid, for lime instantly attracts carbonic acid from magnesia.

When a magnesian limestone is burnt, the magnesia is deprived of carbonic acid much sooner than the lime; and if there is not much vegetable or animal matter in the soil to supply by its decomposition carbonic acid, the magnesia will remain for a long while in the caustic state; and in this state acts as a poison to certain vegetables. And that more magnesian lime may be used upon rich soils, seems to be owing to the circumstance, that the decomposition of the manure in them supplies carbonic acid. And magnesia in its mild state, *i. e.* fully combined with carbonic acid, seems to be always a useful constituent of soils. I have thrown carbonate of magnesia (procured by boiling the solution of magnesia in super-carbonate of potassa) upon grass, and upon growing wheat and barley, so as to render the surface white: but the vegetation was not injured in the slightest degree. And one of the most fertile parts of Cornwall, the Lizard, is a district in which the soil contains mild magnesian earth.

The Lizard Downs bear a short and green grass; which feeds sheep, producing excellent mutton; and the cultivated parts are amongst the best corn lands in the country.

That the theory which I have ventured to give of the operation of magnesian lime is not unfounded, is shown by an experiment which I made expressly for the purpose of determining the true nature of the operation of this substance. I took four portions of the same soil: with one I mixed $\frac{1}{20}$ of its weight of caustic magnesia, with another I mixed the same quantity of magnesia and a proportion of a fat decomposing peat equal to one-fourth of the weight of the soil. One portion of soil remained in its natural state: and another was mixed with peat without magnesia. The mixtures were made in December 1806, and in April 1807 barley was sown in all of them. It grew very well in the pure soil; but better in the soil containing the magnesia and peat, and nearly as well in the soil containing peat alone: but in the soil containing the magnesia alone, it rose very feeble, and looked yellow and sickly.

I repeated this experiment in the summer of 1810 with similar results; and I found that the magnesia in the soil mixed with peat became strongly effervescent, whilst the portion in the unmixed soil gave carbonic acid in much smaller quantities. In the one case the magnesia had assisted in the formation of a manure, and had become mild; in the other case it had acted as a poison.

It is obvious, from what has been said, that lime from the magnesian limestone may be applied in large quantities to peats; and that where lands have been injured by the application of too large a quantity of magnesian lime, peat will be a proper and efficient remedy.

I mentioned that magnesian limestones effervesced little when plunged into an acid. A simple test of magnesia in a limestone is this circumstance, and its rendering diluted nitric acid or aqua fortis milky.

From the analysis of Mr. Tennant, it appears that the magnesian limestones contain from

20·3 to 22·5 magnesia.
29·5 to 31·7 lime.
47·2 carbonic acid.
0·8 clay and oxide of iron.

Magnesian limestones are usually colored brown or a pale yellow. They are found in Somersetshire, Leicestershire, Derbyshire, Shropshire, Durham, and Yorkshire. I have never met with any in other counties in England; but they abound in many parts of Ireland, particularly near Belfast.

The use of lime as a cement is not a proper subject for extensive discussion in a course of lectures

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I have made, I have satisfied myself that it arrests equally vinous and the putrid fermentation, and that in close vessels it may be used for preserving both animal and vegetable substances. When it promotes the solution of vegetable substances, it is probably owing either to forming with them soluble compounds, as in the instance of ulmin, (before mentioned,) or in promoting the production of proximate principles from their elements, capable of entering into union with it, and with which it forms such soluble compounds.—J. D.

on the chemistry of agriculture; yet as the theory of the operation of lime in this way is not fully stated in any elementary book that I have perused, I shall say a very few words on the applications of this part of chemical knowledge.

There are two modes in which lime acts as a cement; in its combination with water, and in its combination with carbonic acid.

The hydrate of lime has been already mentioned. When quicklime is rapidly made into a paste with water, it soon loses its softness, and the water and the lime form together a solid coherent mass, which consists, as has been stated before, of 17 parts of water to 55 parts of lime. When hydrate of lime whilst it is consolidating is mixed with red oxide of iron, alumina, or silica, the mixture becomes harder and more coherent than when lime alone is used; and it appears that this is owing to a certain degree of chemical attraction between hydrate of lime and these bodies; and they render it less liable to decompose by the action of the carbonic acid in the air, and less soluble in water.

The basis of all cements that are used for works which are to be covered with water must be formed from hydrate of lime; and the lime made from impure limestones answers this purpose very well. Puzzolana is composed principally of silica, alumina, and oxide of iron; and it is used mixed with lime, to form cements intended to be employed under water. Mr. Smeaton, in the construction of the Eddystone lighthouse, used a cement composed of equal parts by weight of slacked lime and puzzolana. Puzzolana is a decomposed lava. Tarras, which was formerly imported in considerable quantities from Holland, is a mere decomposed basalt: two parts of slacked lime and one part of tarras form the principal part of the mortar used in the great dikes of Holland. Substances which will answer all the ends of puzzolana and tarras are abundant in the British islands. An excellent red tarras may be procured in any quantities from the Giants' Causeway in the north of Ireland; and decomposing basalt is abundant in many parts of Scotland, and in the northern districts of England in which coal is found.

Parker's cement, and cements of the same kind made at the alum works of Lord Dundas and Lord Mulgrave, are mixtures of calcined ferruginous, siliceous, and aluminous matter, with hydrate of lime.

The cements which act by combining with carbonic acid, or the common mortars, are made by mixing together slacked lime and sand. These mortars at first solidify as hydrates, and are slowly converted into carbonate of lime by the action of the carbonic acid of the air. Mr. Tennant found that a mortar of this kind in three years and a quarter had regained 63 per cent. of the quantity of carbonic acid gas which constitutes the definite proportion in carbonate of lime. The rubbish of mortar from houses owes its power to benefit lands principally to the carbonate of lime it contains, and the sand in it; and its state of cohesion renders it particularly fitted to improve clayey soils.

The hardness of the mortar in very old buildings depends upon the perfect conversion of all its parts into carbonate of lime. The purest limestones are the best adapted for making this kind of mortar; the magnesian limestones make excellent water cements, but act with too little energy upon carbonic acid gas to make good common mortar.

The Romans, according to Pliny, made their best mortar a year before it was used; so that it was partially combined with carbonic acid gas before it was employed.*

In burning lime there are some particular precautions required for the different kinds of limestones. In general, one bushel of coal is sufficient to make four or five bushels of lime. The magnesian limestone requires less fuel than the common limestone. In all cases in which a limestone containing much aluminous or siliceous earth is burnt, great care should be taken to prevent the fire from becoming too intense; for such lime easily vitrifies, in consequence of the affinity of lime for silica and alumina. And as in some places there are no other limestones than such as contain other earths, it is important to attend to this circumstance. A moderately good lime may be made at a low red heat; but it will melt into a glass at a white heat. In lime-kilns for burning such lime, there should be always a damper.

In general, when limestones are not magnesian, their purity will be indicated by their loss of weight in burning; the more they lose, the larger is the quantity of calcareous matter they contain. The magnesian limestones contain more carbonic acid than the common limestones; and I have found all of them lose more than half their weight by calcination.

Besides being used in the forms of lime and carbonate of lime, calcareous matter is applied for the purposes of agriculture in other combinations. One of these bodies is *gypsum* or sulphate of lime. This substance consists of sulphuric acid (the same body that exists combined with water in oil of vitriol) and lime; and when dry it is composed of 55 parts of lime and 75 parts of sulphuric acid. Common gypsum or selenite, such as that found at Shotover Hill near Oxford, contains, besides sulphuric acid and lime, a considerable quantity of water; and its composition may be thus expressed:—

Sulphuric acid, one proportion -	75
Lime, one proportion - - -	55
Water, two proportions - -	34

The nature of gypsum is easily demonstrated: if oil of vitriol be added to quicklime, there is a violent heat produced; when the mixture is ignited, water is given off, and gypsum alone is the result, if the acid has been used in sufficient quantity; and gypsum mixed with quicklime, if the quantity has been deficient. Gypsum free from water is sometimes found in nature, when it is called anhydrous selenite. It is distinguished from common gypsum by giving off no water when heated.

When gypsum, free from water, or deprived of water by heat, is made into a paste with water, it rapidly sets by combining with that fluid. Plaster of Paris is powdered dry gypsum,† and its property as a cement, and in its use in making casts, depends upon its solidifying a certain quan-

* Pliny, speaking of the qualities of mortars, says, "Intrita quoque quo vetustior eo melior. In antiquarum edium legibus invenitur, ne recentiore trima uteretur redemptor." Nat. Hist. lib. xxxvi. cap. 23.—J. D.

† Anhydrous gypsum.

tity of water, and making with it a coherent mass. Gypsum is soluble in about 500 times its weight of cold water, and is more soluble in hot water; so that when water has been boiled in contact with gypsum, crystals of this substance are deposited as the water cools. Gypsum is easily distinguished when dissolved by its properties of affording precipitates to solutions of oxalates and barytic salts.

Great difference of opinion has prevailed amongst agriculturists with respect to the uses of gypsum. It has been advantageously used in Kent, and various testimonies in favor of its efficacy have been laid before the Board of Agriculture by Mr. Smith. In America it is employed with signal success; but in most counties of England it has failed, though tried in various ways and upon different crops.

Very discordant notions have been formed as to the mode of operation of gypsum. It has been supposed by some persons to act by its power of attracting moisture from the air; but this agency must be comparatively insignificant. When *combined* with water, it retains that fluid too powerfully to yield it to the roots of the plant, and its adhesive attraction for moisture is inconsiderable; the small quantity in which it is used, likewise, is a circumstance hostile to this idea.

It has been said that gypsum assists the putrefaction of animal substances, and the decomposition of manure. I have tried some experiments on this subject, which are contradictory to the notion. I mixed some minced veal with about $\frac{1}{100}$ part of its weight of gypsum, and exposed some veal without gypsum under the same circumstances; there was no difference in the time in which they began to putrefy, and the process seemed to me most rapid in the case in which there was no gypsum present. I made other similar mixtures, employing in some cases larger and in some cases smaller quantities of gypsum; and I used pigeons' dung in one instance instead of flesh, and with precisely similar results. It certainly in no case increased the rapidity of putrefaction.

Though it is not generally known, yet a series of experiments has been carried on for a great length of time in this country upon the operation of gypsum as a manure. The Berkshire and the Wiltshire peat-ashes contain a considerable portion of this substance. In the Newbury peat-ashes I have found from one-fourth to one-third of gypsum; and a larger quantity in some peat-ashes from the neighborhood of Stockbridge: the other constituents of these ashes are calcareous, aluminous, and siliceous earth, with variable quantities of sulphate of potassa, a little common salt, and sometimes oxide of iron. The red ashes contain most of this last substance.

These peat-ashes are used as a top-dressing for cultivated grasses, particularly sainfoin and clover. In examining the ashes of sainfoin, clover, and rye grass, I found that they afforded considerable quantities of gypsum; and this substance, probably, is intimately combined as a necessary part of their woody fibre. If this be allowed, it is easy to explain the reason why it operates in such small quantities; for the whole of a clover crop, or sainfoin crop, on an acre, according to my estimation, would afford by incineration only three or four bushels of gypsum. In examining the soil in a field near Newbury, which was taken from below a footpath near the gate, where gypsum could not have been artificially furnished, I could not detect any of this substance in it; and at the very time I collected the soil, the peat-ashes were applied to the clover in the field. The reason why gypsum is not generally efficacious, is probably because most cultivated soils contain it in sufficient quantities for the use of the grasses. In the common course of cultivation, gypsum is furnished in the manure; for it is contained in stable dung, and in the dung of all cattle fed on grass; and it is not taken up in corn crops, or crops of peas and beans, and in very small quantities in turnip crops; but where lands are exclusively devoted to pasturage and hay, it will be continually consumed. I have examined four different soils, cultivated by a series of common courses of crops, for gypsum. One was a light sand from Norfolk; another a clay, bearing good wheat, from Middlesex; the third a sand from Sussex; the fourth a clay from Essex. I found gypsum in all of them; and in the Middlesex soil it amounted nearly to one per cent. Lord Dundas informs me, that having tried gypsum without any benefit on two of his estates in Yorkshire, he was induced to have the soil examined for gypsum, according to the process described in the fourth lecture, and this substance was found in both the soils.

Should these statements be confirmed by future inquiries, a practical inference of some value may be derived from them. It is possible that lands which have ceased to bear good crops of clover, or artificial grasses, may be restored by being manured with gypsum. I have mentioned that this substance is found in Oxfordshire; it is likewise abundant in many other parts of England; in Gloucestershire, Somersetshire, Derbyshire, Yorkshire, &c.; and requires only pulverisation for its preparation.*

Some very interesting documents upon the use of sulphate of iron or green vitriol, which is a salt produced from peat in Bedfordshire, have been laid before the Board by Dr. Pearson; and I have witnessed the fertilizing effects of a ferruginous water used for irrigating a grass meadow made by the Duke of Manchester, at Priestley Bog, near Woburn, an account of the produce of which has been published by the Board of Agriculture. I have no doubt that the peat salt and the vitriolic water acted chiefly by producing gypsum.

The soils on which both are efficacious are calcareous; and sulphate of iron is decomposed by the carbonate of lime in such soils. The sulphate of iron consists of sulphuric acid and oxide of iron, and is an acid and a very soluble salt: when a solution of it is mixed with carbonate of lime, the sulphuric acid quits the oxide of iron to unite to the lime, and the compounds produced are insipid and comparatively insoluble.

I collected some of the deposition from the ferruginous water on the soil in Priestley meadow. I found it consisted of gypsum, carbonate or iron,

* The manner in which gypsum acts in promoting the vegetation of the grasses, is still a disputed question. M. De Candolle rejects the opinion expressed in the text, and adopts that of M. Soquet, somewhat modified; he thinks that gypsum is not so much useful in the soil, if indeed it is at all, as when scattered on the surface, and that it acts chiefly by stimulating the leaves of the plants to which it adheres. (Vide Physiologie Végétale, p. 1273.—J. D.

and insoluble sulphate of iron. The principal grasses in Priestley meadow are, meadow fox-tail, cock's-foot, meadow fescue, fiorin, and sweet-scented vernal grass. I have examined the ashes of three of these grasses, meadow fox-tail, cock's-foot, and fiorin. They contained a considerable proportion of gypsum.

Vitriolic impregnations, in soils where there is no calcareous matter, as in a soil from Lincolnshire, to which I referred in the fourth lecture, are injurious; but it is probably in consequence of their supplying an excess of ferruginous matter to the sap. Oxide of iron in small quantities forms a useful part of soils; and, as is evident from the details in the third lecture, it is found in the ashes of plants; and probably, is hurtful only in its acid combinations.

I have just mentioned certain peats, the ashes of which afford gypsum; but it must not be inferred from this that all peats agree with them. I have examined various peat-ashes from Scotland, Ireland, Wales, and the northern and western parts of England, which contained no quantity that could be useful; and these ashes abounded in siliceous, aluminous earths, and oxide of iron.

Lord Charleville found in some peat-ashes from Ireland sulphate of potassa, *i. e.* the sulphuric acid combined with potassa.

Vitriolic matter is usually formed in peats; and if the soil or substratum is calcareous, the ultimate result is the production of gypsum. In general, when a recent peat-ash emits a strong smell resembling that of rotten eggs when acted upon by vinegar, it will furnish gypsum.

Phosphate of lime is a combination of phosphoric acid and lime, one proportion of each. It is a compound insoluble in pure water, but soluble in water containing any acid matter. It forms the greatest part of calcined bones. It exists in most excrementitious substances, and is found both in the straw and grain of wheat, barley, oats, and rye, and likewise in beans, peas, and tares. It exists in some places in these islands native; but only in very small quantities. Phosphate of lime is generally conveyed to the land in the composition of other manure; and it is probably necessary to corn crops and other white crops.

Bone-ashes ground to powder will probably be found useful on arable lands containing much vegetable matter, and may perhaps enable soft peats to produce wheat; but the powdered bone in an uncalcined state is much to be preferred in all cases when it can be procured.

The *saline compounds of magnesia* will require very little discussion as to their uses as manures. The most important relations of this subject to agriculture have been considered in the former part of this lecture, when the application of the magnesian limestone was examined. In combination with sulphuric acid magnesia forms a soluble salt. This substance, it is stated by some inquirers, has been found of use as a manure; but it is not found in nature in sufficient abundance, nor is it capable of being made artificially sufficiently cheap to be of useful application in the common course of husbandry.

Wood ashes consist principally of the vegetable alkali united to carbonic acid; and as this alkali is found in almost all plants, it is not difficult to conceive that it may form an essential part of their organs. The general tendency of the alkalies is to give solubility to vegetable matters; and in this way they may render carbonaceous and other substances capable of being taken up by the tubes in the radicle fibres of plants. The vegetable alkali, likewise, has a strong attraction for water, and even in small quantities may tend to give a due degree of moisture to the soil, or to other manures*; though this operation, from the small quantities used, or existing in the soil, can be only of a secondary kind.

The *mineral alkali or soda* is found in the ashes of sea-weed, and may be procured by certain chemical agencies from *common salt*. Common salt consists of the metal named sodium combined with chlorine; and pure soda consists of the same metal united to oxygen. When water is present which can afford oxygen to the sodium, soda may be obtained in several modes from salt.

The same reasoning will apply to the operation of the pure mineral alkali, or the carbonated alkali, as to that of the vegetable alkali; and when common salt acts as a manure, it is probably by entering into the composition of the plant in the same manner as gypsum, phosphate of lime, and the alkalies. Sir John Pringle has stated that salt in small quantities assists the decomposition of animal and vegetable matter. This circumstance may render it useful in certain soils. Common salt likewise is offensive to insects. That in small quantities it is sometimes a useful manure, I believe is fully proved; and it is probable that its efficacy depends upon many combined causes.

Some persons have argued against the employment of salt; because, when used in large quantities, it either does no good, or renders the ground steril; but this is a very unfair mode of reasoning. That salt in large quantities rendered land barren, was known long before any records of agricultural science existed. We read in the Scriptures, that Abimelech took the city of Shechem, "and beat down the city, and sowed it with salt," that the soil might be for ever unfruitful. Virgil reprobates a salt soil; and Pliny, though he recommends giving salt to cattle, yet affirms that when strewed over land it renders it barren. But these are not arguments against a proper application of it. Refuse salt in Cornwall, which, however, likewise contains some of the oil and exuviæ of fish, has long been known as an admirable manure. And the Cheshire farmers contend for the benefit of the peculiar produce of their country. It is not unlikely that the same causes influence the effects of salt as those which act in modifying the operation of gypsum. Most lands in this island, particularly those near the sea, probably contain a sufficient quantity of salt for all the purposes of vegetation; and in such cases the supply of it to the soil will not only be useless, but may be injurious. In great storms the spray of the sea has been carried more than 50 miles from the shore; so that from this source salt must be often supplied to the soil. I have found salt in all the sandstone rocks that I have examined, and it must

* This effect is well illustrated by the dampness of walls and floors impregnated with minute quantities of deliquescent salts, such as exist in sea-water. In further illustration, I may mention a striking instance of dampness, amounting to a constant dropping of water, from the ceiling of an uninhabited room impregnated with salt, from brine having been spilt on the floor of the room above some years previously.—J. D.

exist in the soil derived from these rocks. It is a constituent, likewise, of almost every kind of animal and vegetable manure.

Besides these compounds of the alkaline earths and alkalies, many others have been recommended for the purpose of increasing vegetation; such as *nitre*, or the nitrous acid combined with potassa. Sir Kenelm Digby states, that he made barley grow very luxuriantly by watering it with a very weak solution of nitre; but he is too speculative a writer to awaken confidence in his results. This substance consists of one proportion of azote, six of oxygen, and one of potassium; and it is not unlikely that it may furnish azote to form albumen or gluten in those plants that contain them; but the nitrous salts are too valuable for other purposes to be used as manures.

Dr. Home states that *sulphate of potassa*, which as I just now mentioned is found in the ashes of some peats, is a useful manure. But Mr. Naismith* questions his results; and quotes experiments hostile to his opinion, and, as he conceives, unfavorable to the efficacy of any species of saline manure.

Much of the discordance of the evidence relating to the efficacy of saline substances depends upon the circumstance of their having been used in different proportions, and in general in quantities much too large.

I made a number of experiments in May and June, 1807, on the effects of different saline substances on barley and on grass growing in the same garden, the soil of which was a light sand, of which 100 parts were composed of 60 parts of siliceous sand, and 24 parts finely divided matter, consisting of 7 parts carbonate of lime, 12 parts alumina and silica, less than one part saline matter, principally common salt, with a trace of gypsum and sulphate of magnesia: the remaining 16 parts were vegetable matter.

The solutions of the saline substances were used twice a week in the quantity of two ounces, on spots of grass and corn, sufficiently remote from each other to prevent any interference of results. The substances tried were *super-carbonate, sulphate, acetate, nitrate* and *muriate of potassa; sulphate of soda, sulphate, nitrate, muriate*, and *carbonate of ammonia*. I found that in all cases when the quantity of the salt equalled $\frac{1}{30}$ part of the weight of the water, the effects were injurious; but least so in the instances of the carbonate, sulphate, and muriate of ammonia. When the quantities of the salts where $\frac{1}{300}$ part of the solution, the effects were different. The plants watered with the solutions of the sulphates grew just in the same manner as similar plants watered with rain water. Those acted on by the solution of nitre, acetate, and supercarbonate of potassa, and muriate of ammonia, grew rather better.—Those treated with the solution of carbonate of ammonia grew most luxuriantly of all. This last result is what might be expected, for carbonate of ammonia consists of carbon, hydrogen, azote, and oxygen. There was, however, another result which I had not anticipated; the plants watered with solution of nitrate of ammonia did not grow better than those watered with rain water. The solution reddened litmus paper; and probably the free acid exerted a prejudicial effect, and interfered with the result.

Soot doubtless owes a part of its efficacy to the ammoniacal salt it contains. The liquor produced by the distillation of coal contains carbonate and acetate of ammonia, and is said to be a very good manure.

In 1808, I found the growth of wheat in a field at Roehampton assisted by a very weak solution of acetate of ammonia.

Soapers' waste has been recommended as a manure, and it has been supposed that its efficacy depended upon the different saline matters it contains; but their quantity is very minute, indeed, and its principal ingredients are mild lime and quicklime. In the soapers' waste from the best manufactories, there is scarcely a trace of alkali. Lime moistened with sea-water affords more of this substance, and is said to have been used in some cases with more benefit than common lime.

Mr. Knight informs me, that he has found, in the two last seasons, that pond mud, of very poor quality, chiefly clay, having been mixed with coal dust, to afford fuel for his hot-houses, afforded a manure of considerable power. It acts, however, much more beneficially upon soils which are in tolerably good condition, and perhaps rather stimulates than feeds; for on very poor soil, where some was laid in the last winter, its effects can scarcely be perceived.

It is unnecessary to discuss to any greater extent the effects of saline substances on vegetation; except the ammoniacal compounds, or the compounds containing nitric, acetic, and carbonic acid, none of them can afford by their decomposition any of the common principles of vegetation, carbon, hydrogen, and oxygen.

The alkaline sulphates and the earthy muriates are so seldom found in plants, or are found in such minute quantities, that it can never be an object to apply them to the soil. It was stated in the beginning of this lecture, that the earthy and alkaline substances seem never to be formed in vegetation; and there is every reason likewise to believe that they are never decomposed; for after being absorbed they are found in their ashes.

The metallic bases of them cannot exist in contact with aqueous fluids; and these metallic bases, like other metals, have not as yet been resolved into any other forms of matter by artificial processes; they combine readily with other elements; but they remain undestructible, and can be traced undiminished in quantity, through their diversified combinations.

LECTURE VIII.

ON THE IMPROVEMENT OF LANDS BY BURNING; CHEMICAL PRINCIPLES OF THIS OPERATION. ON IRRIGATION AND ITS EFFECTS. ON FALLOWING; ITS DISADVANTAGES AND USES. ON THE CONVERTIBLE HUSBANDRY FOUNDED ON REGULAR ROTATIONS ON DIFFERENT CROPS. ON PASTURE; VIEWS CONNECTED WITH ITS APPLICATION. ON VARIOUS AGRICULTURAL OBJECTS CONNECTED WITH CHEMISTRY. CONCLUSION.

The improvement of steril lands by burning was known to the Romans. It is mentioned by

* Elements of Agriculture, p. 78.

Virgil in the first book of the Georgics: "Sæpe etiam steriles incendere profuit agros." It is a practice still much in use in many parts of these islands; the theory of its operation has occasioned much discussion, both among scientific men and farmers. It rests entirely upon chemical doctrines; and I trust I shall be able to offer you satisfactory elucidations on the subject.

The bases of all common soils, as I stated in the fourth lecture, are mixtures of the primitive earths and oxide of iron; and these earths have a certain degree of attraction for each other. To regard this attraction in its proper point of view, it is only necessary to consider the composition of any common siliceous stone. Feldspar, for instance, contains siliceous, aluminous, calcareous earths, fixed alkali, and oxide of iron, which exist in one compound, in consequence of their chemical attractions for each other. Let this stone be ground into impalpable powder, it then becomes a substance like clay: if the powder be heated very strongly it fuses, and on cooling forms a coherent mass similar to the original stone; the parts separated by mechanical division adhere again in consequence of chemical attraction. If the powder is heated less strongly, the particles only superficially combine with each other, and form a gritty mass, which, when broken into pieces, has the characters of sand.

If the power of the powdered feldspar to absorb water from the atmosphere, before and after the application of the heat, be compared, it is found much less in the last case.

The same effect takes place when the powder of other siliceous or aluminous stones is made the subject of experiment.

I found that two equal portions of basalt ground into impalpable powder, of which one had been strongly ignited, and the other exposed only to a temperature equal to that of boiling water, gained very different weights in the same time when exposed to air. In four hours the one had gained only two grains, whilst the other had gained seven grains.

When clay or tenacious soils are burnt, the effect is of the same kind; they are brought nearer to a state analogous to that of sands.

In the manufacture of bricks the general principle is well illustrated; if a piece of dry brick earth be applied to the tongue, it will adhere to it very strongly, in consequence of its power to absorb water; but after it has been burnt there will be scarcely a sensible adhesion.*

The process of burning renders the soil less compact, less tenacious and retentive of moisture; and when properly applied, may convert a matter that was stiff, damp, and in consequence cold, into one powdery, dry, and warm; and much more proper as a bed for vegetable life.

The great objection made by speculative chemists to paring and burning is, that it destroys vegetable and animal matter, or the manure in the soil; but in cases in which the texture of its earthy ingredients is permanently improved, there is more than a compensation for this temporary disadvantage. And in some soils where there is an excess of inert vegetable matter, the destruction of it must be beneficial: and the carbonaceous matter remaining in the ashes may be more useful to the crop than the vegetable fibre from which it was produced.

I have examined by a chemical analysis three specimens of ashes, from different lands that had undergone paring and burning. The first was a quantity sent to the board by Mr. Boys of Bellhanger, in Kent, whose treatise on paring and burning has been published. They were from a chalk soil, and 200 grains contained

80 Carbonate of lime.
11 Gypsum.
9 Charcoal.
15 Oxide of iron.
3 Saline matter; viz. sulphate of potash, muriate of magnesia, with a minute quantity of vegetable alkali.

The remainder alumina and silica.

Mr. Boys estimates that 2660 bushels are the common produce of an acre of ground, which, according to his calculation, would give 172900 lbs. containing

Carbonate of lime	-	69160 *lbs.*
Gypsum	- -	9509·5
Oxide of iron	-	12967·5
Saline matter	-	2593·5
Charcoal	- -	7780·5

In this instance there was undoubtedly a very considerable quantity of matter capable of being active as manure produced in the operation of burning. The charcoal was very finely divided; and, exposed on a large surface on the field, must have been gradually converted into carbonic acid. And gypsum and oxide of iron, as I mentioned in the last lecture, seem to produce the very best effects when applied to lands containing an excess of carbonate of lime.

The second specimen was from a soil near Coleorton, in Leicestershire, containing only four per cent. of carbonate of lime, and consisting of three-fourths light siliceous sand, and about one-fourth clay. This had been turf before burning, and 100 parts of the ashes gave

6 Parts charcoal.
3 Muriate of soda and sulphate of potash, with a trace of vegetable alkali.
9 Oxide of iron.

And the remainder the earths.

In this instance, as in the other, finely divided charcoal was found; the solubility of which would be increased by the presence of the alkali.

The third instance was that of a stiff clay, from Mount's Bay, Cornwall. This land had been brought into cultivation from a heath by burning about ten years before; but having been neglected, furze was springing up in different parts of it, which gave rise to the second paring and burning: 100 parts of the ashes contained

8 Parts of charcoal.
2 Of saline matter, principally common salt, with a little vegetable alkali.
7 Oxide of iron.
2 Carbonate of lime.

Remainder alumina and silica.

Here the quantity of charcoal was greater than in the other instances. The salt, I suspect, was owing to the vicinity of the sea, it being but two miles off. In this land there was certainly an excess of dead vegetable fibre, as well as unprofita-

* Clay has the remarkable property of confining water; and therefore a thin layer of clay may have a very injurious effect, by preventing rain water from penetrating deeply and saturating the subsoil; an evil which may be corrected by paring and burning.—J. D.

ble living vegetable matter; and I have since heard that a great improvement took place.

Many obscure causes have been referred to for the purpose of explaining the effects of paring and burning; but I believe they may be referred entirely to the diminution of the coherence and tenacity of clays, and to the destruction of inert and useless vegetable matter, and its conversion into a manure.

Dr. Darwin, in his Phytologia, has supposed that clay during torrefaction may absorb some nutritive principles from the atmosphere that afterwards may be supplied to plants; but the earths are pure metallic oxides, saturated with oxygen; and the tendency of burning is to expel any other volatile principles that they may contain in combination. If the oxide of iron in soils is not saturated with oxygen, torrefaction tends to produce its further union with this principle; and hence in burning the color of clays changes to red. The oxide of iron containing its full proportion of oxygen has less attraction for acids than the other oxide, and is consequently less likely to be dissolved by any fluid acid in the soil; and it appears in this state to act in the same manner as the earths. A very ingenious author, whom I quoted at the end of the last lecture, supposes that the oxide of iron when combined with carbonic acid is poisonous to plants, and that one use of torrefaction is to expel the carbonic acid from it; but the carbonate of iron is not soluble in water, and is a very inert substance; and I have raised a luxuriant crop of cresses in a soil composed of one-fifth carbonate of iron, and four-fifths carbonate of lime. Carbonate of iron abounds in some of the most fertile soils in England, particularly the red hop soil. And there is no theoretical ground for supposing that carbonic acid, which is an essential food of plants, should in any of its combinations be poisonous to them; and it is known that lime and magnesia are both noxious to vegetation unless combined with this principle.

All soils that contain too much dead vegetable fibre, and which consequently lose from one-third to one-half of their weight by incineration, and all such as contain their earthy constituents in an impalpable state of division, *i. e.* the stiff clays and marls, are improved by burning; but in coarse sands, or rich soils containing a just mixture of the earths, and in all cases in which the texture is already sufficiently loose, or the organisable matter sufficiently soluble, the process of torrefaction cannot be useful.

All poor siliceous sands must be injured by it; and here practice is found to accord with theory. Mr. Young, in his Essay on Manures, states, "that he found burning injure sand;" and the operation is never performed by good agriculturists upon siliceous sandy soils, after they have once been brought into cultivation.

An intelligent farmer in Mount's Bay told me that he had pared and burned a small field several years ago, which he had not been able to bring again into good condition. I examined the spot; the grass was very poor and scanty, and the soil an arid siliceous sand.

Irrigation, or *watering land*, is a practice which, at first view, appears the reverse of torrefaction; and in general, in nature, the operation of water is to bring earthy substances into an extreme state of division. But in the artificial watering of meadows, the beneficial effects depend upon many different causes,—some chemical, some mechanical.

Water is absolutely essential to vegetation; and when land has been covered by water in the winter, or in the beginning of spring, the moisture that has penetrated deep into the soil, and even the sub-soil, becomes a source of nourishment to the roots of the plant in the summer, and prevents those bad effects that often happen in lands in their natural state, from a long continuance of dry weather.

When the water used in irrigation has flowed over a calcareous country, it is generally found impregnated with carbonate of lime; and in this state it tends, in many instances, to ameliorate the soil.*

Common river-water, also, generally contains a certain portion of organisable matter, which is much greater after rains than at other times; and which exists in the largest quantity when the stream rises in a cultivated country.

Even in cases when the water used for flooding is pure, and free from animal or vegetable substances, it acts by causing the more equable diffusion of nutritive matter existing in the land; and in very cold seasons it preserves the tender roots and leaves of the grass from being affected by frost.

Water is of greater specific gravity at 42° Fahrenheit, than at 32°; the freezing point; and hence in a meadow irrigated in winter, the water immediately in contact with the grass is rarely below 40°, a degree of temperature not at all prejudicial to the living organs of plants.

In 1804, in the month of March, I examined the temperature in a water meadow near Hungerford, in Berkshire, by a very delicate thermometer. The temperature of the air at seven in the morning was 29°. The water was frozen above the grass. The temperature of the soil below the water in which the roots of the grass were fixed was 43°.

In general those waters which breed the best fish are the best fitted for watering meadows; but most of the benefits of irrigation may be derived from any kind of water. It is, however, a general principle, that waters containing ferruginous impregnations, though possessed of fertilizing effects, when applied to a calcareous soil, are injurious on soils that do not effervesce with acids; and that calcareous waters, which are known by the earthy deposite they afford when boiled, are of most use on siliceous soils, or other soils containing no remarkable quantity of carbonate of lime.

The most important processes for improving land are those which have been already discussed, and that are founded upon the circumstance of removing certain constituents from the soil, or adding others, or changing their nature; but there is an operation of very ancient practice still much

* And, I may add, to counteract the effect of rain-water, to dissolve and remove carbonate of lime from the soil. In Malta, where irrigation is much employed, the water containing carbonate of lime, I have found no deficiency of this compound in the soil of the irrigated lands; but in this country, even in chalk districts, the superficial soil is often entirely destitute of carbonate of lime; it has been removed in process of time, supposing that it previously existed in the soil, by the solvent power of rain-water.—J. D.

employed, in which the soil is exposed to the air, and submitted to processes which are purely mechanical, namely, *following*.

The benefits arising from fallows have been much overrated. A summer fallow, or a clean fallow, may be sometimes necessary in lands overgrown with weeds, particularly if they are sands which cannot be pared and burnt with advantage; but is certainly unprofitable as part of a general system in husbandry.

It has been supposed by some writers, that certain principles necessary to fertility are derived from the atmosphere, which are exhausted by a succession of crops, and that these are again supplied during the repose of the land, and the exposure of the pulverized soil to the influence of the air; but this, as was mentioned in the introductory lecture, is not a correct statement. Oxygen is absorbed by the vegetable film, and, perhaps, in certain cases, azote; but the earths, the great elements of soils, cannot be combined with new elements from the air; none of them unite to azote; and such of them as are capable of attracting carbonic acid, are always saturated with it in those soils on which the practice of fallowing is adopted. The vague ancient opinion of the use of nitre and of nitrous salts in vegetation, seems to have been one of the principal speculative reasons for the defence of summer fallows. Nitrous salts are produced during the exposure of soils containing vegetable and animal remains, and in greatest abundance in hot weather;* but it is probably by the combination of azote from these remains with oxygen in the atmosphere that the acid is formed, and at the expense of an element which otherwise would have formed ammonia; the compounds of which, as is evident from what is stated in the last lecture, are much more efficacious than the nitrous compounds in assisting vegetation.

When weeds are buried in the soil, by their absorption of oxygen and gradual decomposition they furnish a certain quantity of soluble matter, and a soil will certainly in consequence produce better crops at the end of a fallow; but the use of this practice must depend upon the quantity of vegetable fibre and its nature, and upon the quality of the soil. Carbonic acid gas is formed during the whole time by the action of the vegetable matter upon the oxygen of the air, and the greater part of it is lost to the soil in which it was formed, and dissipated in the atmosphere.

The action of the sun upon the surface of the soil tends to disengage the gaseous and the volatile fluid matters that it contains; and heat increases the rapidity of fermentation: and in the summer fallow, nourishment is rapidly produced, at a time when no vegetables are present capable of absorbing it.

Land, when it is not employed in preparing food for animals, should be applied to the purpose of the preparation of manure for plants; and this is effected by means of green crops, in consequence of the absorption of carbonaceous matter in the carbonic acid of the atmosphere. In a summer's fallow a period is always lost in which vegetables may be raised, either as food for animals, or as nourishment for the next crop; and the texture of the soil is not so much improved by it exposure as in winter, when the expansive powers of ice, the gradual dissolution of snows, and the alternations from wet to dry, tend to pulverize it, and to mix its different parts together.

In the drill husbandry the land is preserved clean by the extirpation of the weeds by hand, by raising the crops in rows, which renders the destruction of the weeds much more easy. Manure is supplied either by the green crops themselves, or from the dung of the cattle fed upon them; and the plants having large systems of leaves are made to alternate with those bearing grain.

It is a great advantage in the convertible system of cultivation, that the whole of the manure is employed; and that those parts of it which are not fitted for one crop remain as nourishment for another. Thus, in Mr. Coke's course of crops, the turnip is the first in the order of succession; and this crop is manured with recent dung, which immediately affords sufficient soluble matter for its nourishment; and the heat produced in fermentation assists the germination of the seed and the growth of the plant. After turnips, barley with grass seeds is sown; and the land, having been little exhausted by the turnip crop, affords the soluble parts of the decomposing manure to the grain. The grasses, rye-grass, and clover remain, which derive a small part only of their organized matter from the soil, and probably consume the gypsum in the manure, which would be useless to other crops: these plants, likewise, by their large systems of leaves, absorb a considerable quantity of nourishment from the atmosphere; and when ploughed in at the end of two years, the decay of their roots and leaves affords manure for the wheat crop: and at this period of the course, the woody fibre of the farm-yard manure, which contains the phosphate of lime and the other difficultly soluble parts, is broken down; and as soon as the most exhausting crop is taken, recent manure is again applied.

Mr. Gregg, whose ingenious system of cultivation has been published by the Board of Agriculture, and who has the merit of first adopting a plan similar to Mr. Coke's upon strong clays, suffers the ground after barley to remain at rest for two years in grass: sows peas and beans on the leys; ploughs in the pea or bean stubble for wheat; and in some instances follows his wheat crops by a course of winter tares and winter barley, which is eat off in the spring, before the land is sowed for turnips.

Peas and beans, in all instances, seem well adapted to prepare the ground for wheat; and in some rich lands, as in the alluvial soil of the Parret, mentioned in the fourth lecture, and at the foot of the South Downs in Sussex, they are raised in alternate crops for years together. Peas and beans contain, as appears from the analyses in the third lecture, a small quantity of matter analogous to albumen; but it seems that the azote, which forms a constituent part of this matter, is derived from the atmosphere. The dry bean leaf, when burnt, yields a smell approaching to that of decomposing animal matter; and in its decay in the

* Nitre and nitrate of lime are the two nitrous salts of most common occurrence; the presence of lime appears to be essential to the production of both. In situations, however favorable in other respects, in which there is no potash pre-existing, there nitre will not form; nitrate of lime will appear alone. Nitre, therefore, is chiefly confined to countries of primary rock formations, containing feldspar or some analogous mineral, which in decomposing yields potassa.—J. D.

soil, may furnish principles capable of becoming a part of the gluten in wheat.

In considering what vegetables are likely to be profitable on a particular *soil*, it is necessary always to attend, not only to the mean temperature of the climate, but likewise to the summer's heat and winter's cold. Thus, maize, or Indian corn, and the vine, require a very hot summer; and the olive would be destroyed by our winter. It is unnecessary, therefore, to say any thing of these plants, or similar plants, in relation to a British system of cultivation: but, in some of our colonies, particularly the Cape of Good Hope, almost all the vegetable productions of Italy, Portugal, or Spain, are or may be raised. The wines of the Cape may be doubtless improved by a proper selection of soils, and by employing peasants from the vine countries of France in cultivating the grape, and in the manufacture of wine. The flavor of the juice of the grape changes as the soil is different; and in selecting a place for a vineyard, much may be gained by analyses or chemical examination of the soil, and by comparing it with the best soils of the best wine provinces of France, Germany, and Spain. This is a subject not unworthy the attention of our government.

Though the general composition of plants is very analogous, yet the specific difference in the products of many of them, and the facts stated in the last lecture, prove that they must derive different materials from the soil; and though the vegetables having the smallest systems of leaves will proportionably most exhaust the soil of common nutritive matter, yet particular vegetables, when their produce is carried off, will require peculiar principles to be supplied to the land in which they grow. Strawberries and potatoes at first produce luxuriantly in virgin mould recently turned up from pasture; but in a few years they degenerate, and require fresh soil; and the organisation of these plants is such, as to be constantly producing the migration of their layers: thus the strawberry by its long shoots is constantly endeavoring to occupy a new soil; and the fibrous radicles of the potato produce bulbs at a considerable distance from the parent plant. Lands in a course of years often cease to afford good cultivated grasses; they become (as it is popularly said) tired of them; and one of the probable reasons for this was stated in the last lecture.

The most remarkable instance of the powers of vegetables to exhaust the soil of certain principles necessary to their growth, is found in certain funguses. Mushrooms are said never to rise in two successive seasons on the same spot, and the production of the phenomena called fairy wings has been ascribed by Dr. Wollaston to the power of the peculiar fungus which forms it to exhaust the soil of the nutriment necessary for the growth of the species. The consequence is, that the ring annually extends, for no seeds will grow where their parents grew before them, and the interior part of the circle has been exhausted by preceding crops; but where the fungus has died, nourishment is supplied for grass, which usually rises within the circle, coarse, and of a dark green color.*

When cattle are fed upon land not benefited by their manure, the effect is always an exhaustion of the soil; this is particularly the case where carrying horses are kept on estates; they consume the pasture during the night, and drop the greatest part of their manure during their labor in the day-time.

The exportation of grain from a country, unless some articles capable of becoming manure are introduced in compensation, must ultimately tend to exhaust the soil. Some of the spots now desert sands in northern Africa, and Asia Minor, were anciently fertile. Sicily was the granary of Italy; and the quantity of corn carried off from it by the Romans is probably a chief cause of its present sterility.* In this island, our commercial system at present has the effect of affording substances, which in their use and decomposition must enrich the land. Corn, sugar, tallow, oil, skins, furs, wine, silk, cotton, &c., are imported, and fish are supplied from the sea. Amongst our numerous exports, woollen, and linen, and leather goods are almost the only substances which contain any nutritive materials derived from the soil.

In all courses of crops it is necessary that every part of the soil should be made as useful as possible to the different plants; but the depth of the furrow in ploughing must depend upon the nature of the soil, and of the subsoil. In rich clayey soils the furrow can scarcely be too deep; and even in sands, unless the subsoil contains some principles noxious to vegetables, the same practice should be adopted. When the roots are deep, they are less liable to be injured, either by excess of rain, or drought; the layers shoot forth their radicles into every part of the soil; and the space from which the nourishment is derived is more considerable, than when the seed is superficially inserted in the soil.

There has been much difference of opinion with respect to permanent pasture; but the advantages or disadvantages can only be reasoned upon according to the circumstances of situation and climate. Under the circumstances of irrigation, lands are extremely productive, with comparatively little labor; and in climates where great quantites of rain fall, the natural irrigation produces the same effects as artificial. When hay is in great demand, as sometimes happens in the neighborhood of the metropolis, where manure

* Some effects attributed to exhaustion of soil may be owing to excretions from the roots, injurious to the plants which have yielded them, and yet beneficial to other kinds of plants: in one instance acting the part of a poison, in the other of a manure. *Vide* Phisiologie Végétale, pp. 248 and 1474, for some curious information on this important subject, the investigation of which is only just begun.—J. D.

* Sicily is still abundant in corn, and produces more than is sufficient for the use of its inhabitants. If its fertility is diminished, which there is reason to believe is the case, since the best times of the Romans, it may be referred to a bad system of agriculture, connected with an oppressive government. The corn-lands of the adjoining little island of Malta, well cultivated, are wonderfully fertile, yielding often a return of fifteen fold of wheat, and sometimes of thirty-two fold of barley; whilst in the Ionian Islands, especially at Cerigo, where the soil is similar, but where manure is not used, and the same land is yearly under the plough, the produce of wheat seldom exceeds five fold; and in all these islands, from time immemorial, corn has been imported, the most fertile of them not yielding sufficient for six months' consumption.—J. D

can be easily procured, the application of it to pasture is repaid by the increase of crop; but top-dressing grass land with animal or vegetable manure cannot be recommended as a general system. Dr. Coventry very justly observes, that there is a greater waste of the manure in this case than when it is ploughed into the soil for seed crops. The loss by exposure to the air and the sunshine offers reasons, in addition to those that have been already quoted in the sixth lecture, for the application of manure, even in this case, in a state of incipient and not completed fermentation.

Very little attention has been paid to the nature of the grasses best adapted for permanent pasture. The chief circumstance which gives value to a grass is the quantity of nutritive matter that the whole crop will afford; but the time and duration of its produce are likewise points of great importance; and a grass that supplies green nutriment throughout the whole of the year may be more valuable than a grass which yields its produce only in summer, though the whole quantity of food supplied by it should be much less.

The grasses that propagate themselves by layers, the different species of agrostis, supply pasture throughout the year; and, as it has been mentioned on a former occasion, the concrete sap stored up in their joints renders them a good food even in winter. I saw four square yards of fiorin grass cut in the end of January, this year, in a meadow exclusively appropriated to the cultivation of fiorin, by the Countess of Hardwicke, the soil of which is a damp stiff clay. They afforded 28 pounds of fodder; of which 1000 parts afforded 64 parts of nutritive matter, consisting nearly of one-sixth of sugar, and five-sixths of mucilage, with a little extractive matter. In another experiment, four square yards gave 27 pounds of grass. The quality of this grass is inferior to that of the fiorin referred to in the table, in the latter part of the third lecture, which was cultivated by Sir Joseph Banks in Middlesex, in a much richer soil, and cut in December.

The fiorin grass, to be in perfection, requires a moist climate or a wet soil; and it grows luxuriantly in cold clays unfitted for other grasses. In light sands and in dry situations its produce is much inferior as to quantity and quality.

The common grasses, properly so called, that afford most nutritive matter in early spring, are the vernal meadow grass and meadow fox-tail grass; but their produce, at the time of flowering and ripening the seed, is inferior to that of a great number of other grasses; their latter-math is, however, abundant.

Tall fescue grass stands highest, according to the experiments of the Duke of Bedford, of any grass properly so called, as to the quantity of nutritive matter afforded by the whole crop when cut at the time of flowering; and meadow cat's-tail grass affords most food when cut at the time the seed is ripe: the highest latter-math produce of the grasses examined in the Duke of Bedford's experiments is from the sea-meadow grass.

Nature has provided in all permanent pastures a mixture of various grasses, the produce of which differs at different seasons. Where pastures are to be made artificially, such a mixture ought to be imitated; and, perhaps, pastures superior to the natural ones may be made by selecting due proportions of those species of grasses fitted for the soil which afford respectively the greatest quantities of spring, summer, latter-math, and winter produce. A reference to the details in the appendix will show that such a plan of cultivation is very practicable.

The propagation of grasses by layers has lately given rise to a considerable improvement in the formation of pasture, by what has been called inoculation. A certain portion of old pasture is removed with the roots of the grasses and a part of the soil, and planted (as it were) in arable land at certain intervals. By the spreading of the layers, a surface of grasses is speedily formed; and the old pasture, if too much of it be not removed, soon recovers itself, in consequence of the operation of the same principle. This improvement has arisen in the same place where agriculture has so long been an object of unremitted and patriotic exertions. Mr. Coke's steward is the author.

In all lands, whether arable or pasture, weeds, of every description, should be rooted out before the seed is ripe; and if they are suffered to remain in hedge-rows, they should be cut when in flower, or before, and made into heaps for manure: in this case they will furnish more nutritive matter in their decomposition; and their increase by the dispersion of seeds will be prevented. The farmer, who suffers weeds to remain till their ripe seeds are shed, and scattered by the winds, is not only hostile to his own interests, but is likewise an enemy to the public: a few thistles neglected soon will stock a farm; and by the light down which is attached to their seeds, they may be distributed over a whole country. Nature has provided such ample resources for the continuance of even the meanest vegetable tribes, that it is very difficult to ensure the destruction of such as are hostile to the agriculturist, even with every precaution. Seeds excluded from the air will remain for years inactive in the soil*, and yet germinate under favorable circumstances; and the different plants, the seeds of which, like those of the thistle and dandelion, are furnished with beards or wings, may be brought from an immense distance. The fleabane of Canada has only lately been found in Europe; and Linnæus supposes that it has been transported from America, by the very light downy plumes with which the seed is provided.

In feeding cattle with green food, there are many advantages in *soiling*, or supplying them with food, where their manure is preserved, out of the field: the plants are less injured when cut than when torn or jagged by the teeth of the cattle, and no food is wasted by being trodden down. They are likewise obliged to feed without making a selection; and in consequence the whole food is con-

* The appearance of seeds in places where their parent plants are not found may be easily accounted for from this circumstance, and other circumstances. Many seeds are carried from island to island by currents in the sea, and are defended by their hard coats from the immediate action of the water. West Indian seeds (of this description) are often found on our coasts, and readily germinate; their long voyage having been barely sufficient to afford the cotyledon its due proportion of moisture. Other seeds are carried indigested in the stomach of birds, and supplied with food at the moment of their deposition. The light seeds of the mosses and lichens probably float in every part of the atmosphere, and abound on the surface of the sea.

sumed: the attachment or dislike to a particular kind of food exhibited by animals, offers no proof of its nutritive powers. Cattle, at first, refuse linseed cake, one of the most nutritive substances on which they can be fed.*

When food artificially composed is to be given to cattle, it should be brought as nearly as possi-

* For the following observations on the selection of different kinds of common food by sheep and cattle, I am obliged to Mr. George Sinclair.

"*Lolium perenne*, rye-grass. Sheep eat this grass when it is in the early stage of its growth, in preference to most others; but after the seed approaches towards perfection, they leave it for almost any other kind. A field in the park at Woburn was laid down in two equal parts; one part with rye-grass and white clover, and the other part with cock's-foot and red clover: from the spring till midsummer the sheep kept almost constantly on the rye-grass; but after that time they left it, and adhered with equal constancy to the cock's-foot during the remainder of the season.

"*Dactylis glomerata*, cock's-foot. Oxen, horses, and sheep eat this grass readily. The oxen continue to eat the straws and flowers, from the time of flowering till the time of perfecting the seed: this was exemplified in a striking manner in the field before alluded to. The oxen generally kept to the cock's-foot and red clover, and the sheep to the rye-grass and white clover. In the experiments published in the Amœnitates Academicæ, by the pupils of Linnæus, it is asserted that this grass is rejected by oxen: the above fact, however, is in contradiction of it.

"*Alopecurus pratensis*, meadow fox-tail. Sheep and horses seem to have a greater relish for this grass than oxen. It delights in a soil of intermediate quality as to moisture or dryness, and is very productive. In the water-meadow at Priestley, it constitutes a considerable part of the produce of that excellent meadow. It there keeps invariably possession of the top of the ridges, extending generally about six feet from each side of the water-course; the space below that to where the ridge ends is stocked with cock's-foot, the rough-stalked meadow grass, *Festuca pratensis*, *Festuca duriuscula*, *Agrostis stolonifera*, *Agrostis palustris*, and sweet-scented vernal grass, with a small admixture of some other kinds.

"*Phleum pratense*, meadow cat's-tail. This grass is eaten without reserve by oxen, sheep, and horses. Dr. Pulteney says that it is disliked by sheep; but in pastures where it abounds, it does not appear to be rejected by these animals, but eaten in common with such others as are growing with it. Hares are remarkably fond of it. The *Phleum nodosum*, *Phleum alpinum*, *Poa fertilis* and *Poa compressa*, were left untouched, although they were closely adjoining to it. It seems to attain the greatest perfection in a rich deep loam.

"*Agrostis stolonifera*, fiorin. In the experiments detailed in the Amœnitates Academicæ, it is said that horses, sheep, and oxen eat this grass readily. On the Duke of Bedford's farm at Maulden, fiorin hay was placed in the racks before horses in small distinct quantities, alternately with common hay; but no decided preference for either was manifested by the horses in this trial. But that cows and horses prefer it to hay, when in a green state, seems fully proved by Dr. Richardson, in his several publications on fiorin; and of its productive powers in England (which have been doubted by some,) there are satisfactory proofs. Lady Hardwicke has given an account of a trial of this grass; wherein twenty-three milch cows and one young horse, besides a number of pigs, were kept a fortnight on the produce of one acre.

"*Poa trivialis*, rough-stalked meadow. Oxen, horses, and sheep eat this grass with avidity. Hares also eat it; but they give a decided preference to the smooth-stalked meadow grass, to which it is, in many respects, nearly allied.

"*Poa pratensis*, smooth-stalked meadow-grass. Oxen and horses are observed to eat this grass in common with others; but sheep rather prefer the hard fescue, and sheep's fescue, which affect a similar soil. This species exhausts the soil in a greater degree than almost any other species of grass; the roots being numerous, and powerfully creeping, become in two or three years completely matted together; the produce diminishes as this takes place. It grows common in some meadows, dry banks, and even on walls.

"*Cynosurus cristatus*, crested dog's-tail grass. The South Down sheep and deer appear to be remarkably fond of this grass: in some parts of Woburn Park this grass forms the principal part of the herbage on which these animals chiefly browse; while another part of the park, that contains the *Agrostis capillaris*, *Agrostis pumilis*, *Festuca ovina*, *Festuca duriuscula*, and *Festuca cambrica*, is seldom touched by them: but the Welsh breed of sheep almost constantly browse upon these, and neglect the *Cynosurus cristatus*, *Lolium perenne*, and *Poa trivialis*.

"*Agrostis vulgaris* (*capillaris*, Linn.), fine bent; common bent. This is a very common grass on all poor dry sandy soils. It is not palatable to cattle, as they never eat it readily, if any other kinds be within their reach. The Welsh sheep, however, prefer it, as I before observed; and it is singular that those sheep being bred in the park, when some of the best grasses are equally within their reach, should still prefer those grasses which naturally grow on the Welsh mountains: it seems to argue that such a preference is the effect of some other cause than that of habit.

"*Festuca ovina*, sheep's fescue. All kinds of cattle relish this grass; but it appears from the trial that has been made with it on clayey soils, that it continues but a short time in possession of such, being soon overpowered by the more luxuriant kinds. On dry shallow soils that are incapable of producing the larger sorts, this should form the principal crop, or rather the whole; for it is seldom or ever, in its natural state, found intimately mixed with others, but by itself.

"*Festuca duriuscula*, hard fescue grass. This is certainly one of the best of the dwarf sorts of grasses. It is grateful to all kinds of cattle; hares are very fond of it; they cropped it close to the roots, and neglected the *Festuca ovina* and *Festuca rubra*, which were contiguous to it. It is present in most good meadows and pastures.

"*Festuca pratensis*, meadow fescue. This grass is seldom absent from rich meadows and pastures; it is observed to be highly grateful to oxen, sheep, and horses, particularly the former. It appears to grow most luxuriantly when combined with the hard fescue and *Poa trivialis*.

"*Avena elatior*, tall oat grass. This is a very productive grass, frequent in meadows and pastures, but is disliked by cattle, particularly by horses; this perfectly agrees with the small portion of nutritive matter which it affords. It seems to thrive best on a strong tenacious clay.

"*Avena flavescens*, yellow oat-grass. This grass seems partial to dry soils and meadows, and appears to be eaten by sheep and oxen equally with the meadow barley, crested dog's-tail, and sweet-scented vernal grasses, which naturally grow in company with it. It nearly doubles the quantity of its produce by the application of calcareous manure.

"*Holcus lanatus*, meadow soft grass. This is a very common grass, and grows on all soils, from the richest to the poorest. It affords an abundance of seed, which is light, and easily dispersed by the wind. It appears to be generally disliked by all sorts of cattle. The produce is not so great as a view of it in fields would indicate; but being left almost entirely untouched by cattle, it appears as the most productive part of the herbage. The hay which is made of it, from the

ble to the state of natural food. Thus, when sugar is given to them, some dry fibrous matter should be mixed with it, such as chopped straw, or dry withered grass, in order that the functions of the stomach and bowels may be performed in a natural manner. The principle is the same as that of the practice alluded to in the third lecture, of giving chopped straw with barley.

In washing sheep, the use of water containing carbonate of lime should be avoided; for this substance decomposes the yolk of the wool, which is an animal soap, the natural defence of the wool; and wool often washed in calcareous water becomes rough and more brittle. The finest wool, such as that of the Spanish and Saxon sheep, is most abundant in yolk. M. Vauquelin has analyzed several different species of yolk, and has found the principal part of all of them a soap, with a basis of potassa (*i. e.* a compound of oily matter and potassa,) with a little oily matter in excess. He has found in them, likewise, a notable quantity of acetate of potassa, and minute quantities of carbonate of potassa, and muriate of potassa, and a peculiar odorous animal matter.

M. Vauquelin states, that he found some specimens of wool lose as much as 45 per cent. in being deprived of their yolk; and the smallest loss in his experiments was 35 per cent.

The yolk is most useful to the wool on the back of the sheep in cold and wet seasons; probably the application of a little soap of potassa, with excess of grease to the sheep brought from warmer climates in our winter, that is, increasing their yolk artificially, might be useful in cases where the fineness of the wool is of great importance. A mixture of this kind is more conformable to nature than that ingeniously adopted by Mr. Bakewell; but at the time his labors commenced the chemical nature of the yolk was unknown.

I have now exhausted all the subjects of discussion, which my experience or information has been able to supply, on the connexion of chemistry with agriculture.

I venture to hope that some of the views brought forward may contribute to the improvement of the most important and useful of the arts.

I trust that the inquiry will be pursued by others; and that, in proportion as chemical philosophy advances towards perfection, it will afford new aids to agriculture.

There are sufficient motives, connected both with pleasure and profit, to encourage ingenious men to pursue this new path of investigation. Science cannot long be despised by any persons as the mere speculation of theorists; but must soon be considered by all ranks of men in its true point of view, as the refinement of common sense, guided by experience, gradually substituting sound and rational principles for vague popular prejudices.

The soil offers inexhastible resources, which when properly appreciated and employed, must increase our wealth, our population, and our physical strength.

We possess advantages in the use of machinery, and the division of labor, belonging to no other nation. And the same energy of character, the same extent of resources which has always distinguished the people of the British Islands, and made them excel in arms, commerce, letters, and philosophy, apply with the happiest effect to the improvement of the cultivation of the earth. Nothing is impossible to labor, aided by ingenuity. The true objects of the agriculturist are likewise those of the patriot. Men value most what they have gained with effort; a just confidence in their own powers results from success; they love their country better, because they have seen it improved by their own talents and industry; and they identify with their interests the existence of those institutions which have afforded them security, independence, and the multiplied enjoyments of civilized life.

APPENDIX.

AN ACCOUNT OF THE RESULTS OF EXPERIMENTS ON THE PRODUCE AND NUTRITIVE QUALITIES OF DIFFERENT GRASSES, AND OTHER PLANTS, USED AS THE FOOD OF ANIMALS. INSTITUTED BY JOHN DUKE OF BEDFORD.

Introduction by Sir H. Davy.

Of the 215 proper grasses which are capable of being cultivated in this climate, two only have been employed to any extent for making artificial pastures,—rye-grass and cock's-foot grass; and their application for this purpose seems to have been rather the result of accident than of any proofs of their superiority over other grasses.

A knowledge of the comparative merits and value of all the different species and varieties of grasses cannot fail to be of the highest importance in practical agriculture. The hope of obtaining this knowledge was the motive that induced the Duke of Bedford to institute this series of experiments.

Spots of ground, each containing four square feet, in the garden at Woburn Abbey, were inclosed by boards in such a manner that there was no lateral communication between the earth included by the boards and that of the garden. The soil was removed in these inclosures, and new soils supplied; or a mixture of soils was made in them, to furnish as far as possible to the different

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number of downy hairs which cover the surface of the leaves, is soft and spongy, and disliked by cattle in general.

"*Anthoxanthum odoratum*, sweet-scented vernal grass. Horses, oxen, and sheep eat this grass; though in pastures where it is combined with the meadow fox-tail, and white clover, cock's-foot, rough-stalked meadow, it is left untouched; from which it would seem unpalatable to cattle. Mr. Grant of Leighton laid down one-half a field of a considerable extent with this grass, combined with white clover. The other half of the field with fox-tail and red clover. The sheep would not touch the sweet-scented vernal, but kept constantly upon the fox-tail. The writer of this saw the field when the grasses were in the highest state of perfection; and hardly any thing could be more satisfactory. Equal quantities of the seeds of white clover were sown with each of the grasses; but from the dwarf nature of the sweet-scented vernal grass, the clover mixed with it had attained to greater luxuriance than that mixed with the meadow fox-tail."

grasses those soils which seem most favorable to their growth; a few varieties being adopted for the purpose of ascertaining the effect of different soils on the same plant.

The grasses were either planted or sown, and their produce cut and collected and dried, at the proper seasons, in summer and autumn, by Mr. Sinclair, his grace's gardener. For the purpose of determining, as far as possible, the nutritive powers of the different species, equal weights of the dry grasses or vegetable substances were acted upon by hot water till all their soluble parts were dissolved; the solution was then evaporated to dryness by a gentle heat in a proper stove, and the matter obtained carefully weighed. This part of the process was likewise conducted with much address and intelligence by Mr. Sinclair, by whom all the following details and calculations are furnished.

The dry extracts, supposed to contain the nutritive matter of the grasses, were sent to me for chemical examination. The composition of some of them is stated in a foregoing table; I shall offer a few chemical observations on others at the end of this appendix. It will be found from the general conclusions, that the mode of determining the nutritive power of the grasses, by the quantity of matter they contain soluble in water, is sufficiently accurate for all the purposes of agricultural investigation.

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I. *Anthoxanthum odoratum.* Engl. Bot. 647. Curt. Lond.

Sweet-scented vernal-grass. Nat. of Britain.

At the time of flowering, the produce from the space of an acre equal to ·000091827364 of a brown sandy loam with manure, is—

	oz.	or lbs. per acre.
Grass, 11 oz. 8 dr.* The produce per acre	125235	0 = 7827 3 0
80 dr. of grass weigh when dry . 21½ dr.	33656	0 = 2103 8 0
The produce of the space, ditto 49.1 8/10		
The weight lost by the produce of one acre in drying . .	. .	5723 10 0
64 dr. of grass afford of nutritive matter 1 dr.	1956	12 = 122 4 12
The produce of the space, ditto . 2.3 5/10		

At the time the seed is ripe, the produce is—

Grass 9 oz. The produce per acre .	98010	0 = 6125 10 0
80 dr. of grass weigh when dry . . 24 dr.	29403	0 = 1837 11 0
The produce of the space, ditto . 43 1/10		
The weight lost by the produce of one acre in drying . .	. .	4287 15 0
64 dr. of grass afford of nutritive matter 3.1 dr.	4977	10 = 311 1 1
The produce of the space, ditto . 7.1¼		
The weight of nutritive matter which is lost by taking the crop at the time the grass is in flower, exceeding half of its value . .	. .	188 12 4

The proportional value which the grass at the time of flowering bears to that at the time the seed is ripe, is as 4 to 13.

The latter-math produce is—

Grass, 10 oz. The produce per acre . .	108900	0 = 6806 4 0
64 dr. of grass afford of nutritive matter 2.1 dr.	3828	8 = 239 4 8

The proportional value which the grass of the latter-math bears to that at the time the seed is ripe, is nearly as 9 to 13.

The smallness of the produce of this grass renders it improper for the purpose of hay; but its early growth, and the superior quantity of nutritive matter which the latter-math affords, compared with the quantity afforded by the grass at the time of flowering, causes it to rank high as a pasture grass, on such soils as are well fitted for its growth; such are peat-bogs, and lands that are deep and moist,

II. *Holcus odoratus.* Host. G. A. Growing in woods.

Sweet-scented soft grass. Nat. of Germany. Flo. Ger. — H. borealis. Growing in moist meadows.

At the time of flowering, the produce from a rich sandy loam is—

Grass, 14 oz. The produce per acre .	152460	0 = 9528 12 0
80 dr. of grass weigh when dry 20.2 dr.	39067	14 = 2441 11 14
The produce of the space, ditto 57.1 3/5		
The weight lost by the produce of one acre in drying . .	.	7087 0 2
64 dr. of grass afford of nutritive matter 4.1 dr.	10124	13 = 610 15 5
The produce of the space, ditto 14.3½		

At the time the seed is ripe, the produce is—

Grass, 40 oz. The produce per acre .	435600	0 = 27225 0 0

* The weight is avoirdupois; lbs. pounds, oz. ounces, dr. drachms. The weights not named are quarters of drachms, and fractions of quarters of drachms; thus 7.1¼ means 7 drachms, 1 quarter of a drachm, and ¼ of a quarter.

	oz.	or lbs. per acre.		
64 dr. of grass weigh when dry . . 28 dr. The produce of the space ditto . . 224	152460	0= 9528	12	0
The weight lost by the produce of one acre in drying . . .		17696	4	0
64 dr. of grass afford of nutritive matter 5.1 dr. The produce of the space, ditto . . 52.2	35732	13= 2233	4	13
The weight of nutritive matter which is lost by taking the crop at the time the grass is in flower, being more than half of its value		1600	8	10

The proportional value which the grass at the time of flowering bears to that at the time the seed is ripe, is as 17 to 21.

The produce of latter-math is—

Grass, 25 oz. The produce per acre . . .	272250	0=17015	10	0
64 dr. of grass afford of nutritive matter 4.1 dr. .	18079	1= 1129	15	1

The grass of the latter-math crop, and of the crop at the time of flowering, taking the whole quantity, and their relative proportions of nutritive matter, are in value nearly as 6 to 10; the value of the grass at the time the seed is ripe exceeds that of the latter-math in proportion as 21 to 17.

Though this is one of the earliest of the flowering grasses, it is tender, and the produce in the spring is inconsiderable. If, however, the quantity of nutritive matter which it affords be compared with that of any of those species which flower nearly at the same time, it will be found greatly superior. It sends forth but a small number of flower-stalks, which are of a slender structure compared to the size of the leaves. This will account in a great measure for the equal quantities of nutritive matter afforded by the grass at the time of flowering, and the latter-math.

III. *Cynosurus cæruleus.* Engl. Bot. 1613. Host. G. A. ii. t. 98.
Blue moor-grass. Nat. of Britain. Sesleria cærulea.

At the time the seed is ripe, the produce from a light sandy soil is—

Grass, 10 oz. The produce per acre . . .	1089000	0=6806	4	0
64 dr. of grass afford of nutritive matter 3.3 dr. . .	6380	13= 398	12	13

The produce of this grass is greater than its appearance would denote; the leaves seldom attain to more than four or five inches in length, and the flower stalks seldom rise to more. Its growth is not rapid after being cropped, nor does it seem to withstand the effects of frost, which, if it happen to be severe and early in the spring, checks it so much as to prevent it from flowering for that season; otherwise the quantity of nutritive matter which the grass affords (for the straws are very inconsiderable) would rank it as a valuable grass for permanent pasture.

IV. *Alopecurus pratensis.* Curt. Lond. Alo. myosuroides. Meadow fox-tail grass. Nat. of Brit. Engl. Bot. 848.

At the time of flowering, the produce from a clayey loam is—

	oz.	or lbs. per acre.		
Grass, 30 oz. The produce per acre . . .	326700	0=20418	12	0
80 dr. of grass weigh when dry . . 24 dr. The produce of the space, ditto . . 336	98010	0= 6125	10	0
The weight lost by the produce of one acre in drying . . .		14293	2	0
64 dr. of grass afford of nutritive matter 1.2 dr. The produce of the space, ditto . . 11.1	7657	0= 478	9	0

The produce from a sandy loam is—

Grass, 12 oz. 8 dr. The produce per acre . .	136125	0= 8507	13	0
80 dr. of grass weigh when dry . . 24 dr. The produce of the space, ditto . . 60	40837	9= 2552	5	8
64 dr. of grass afford of nutritive matter 1 The produce of the space, ditto . . 3.0½	2126	15= 132	14	15

At the time the seed is ripe, the produce from the clayey loam is—

Grass, 19 oz. The produce per acre . . .	206910	0=12931	14	0
80 dr. of grass weigh when dry . . . 36 dr. The produce of the space, ditto . . 136.3⅕	93109	8= 5819	5	2
The weight lost by the produce of one acre in drying . .		7111	8	14
64 dr. of grass afford of nutritive matter 2.1 dr. The produce of the space, ditto . . 9.975	7376	4= 461	0	4
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, being one twenty-fifth part of its value		17	8	11

The proportional value which the grass at the time of flowering bears to that at the time the seed is ripe, is as 6 to 9.

The latter-math produce, from the clayey loam, is—

Grass, 12 oz. The produce per acre . . .	130680	0= 8167	8	0
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto . . 6	4083	12= 255	3	12

The proportional value which the whole of the latter-math crop bears to that at the time the seed is ripe, is as 5 to 9, and to that at the time of flowering, proportionably as 13 to 24.

The above statement clearly shows that there is nearly three-fourths of produce greater from a clayey loam than from a sandy soil, and the grass from the latter is comparatively of less value, in proportion as 4 to 6. The straws produced by the sandy soil are deficient in number, and in every respect less than those from the clayey loam; which will account for the unequal quantities of nutritive matter afforded by them; but the proportional value in which the grass of the latter-math exceeds that of the crop at the time of flowering, is as 4 to 3: a difference which appears extraordinary, when the quantity of flower-stalks which are in the grass at the time of flowering is consi-

dered. In the *Anthoxanthum odoratum* the proportional difference between the grass of these crops is still greater, nearly as 4 to 9: in the *Poa pratensis* they are equal; but in all the latter flowering grasses experimented upon, the flowering straws of which resemble those of the *Alopecurus pratensis*, or *Anthoxanthum odoratum*, the greater proportional value is always, on the contrary, found in the grass of the flowering crop. Whatever the cause may be, it is evident that the loss sustained by taking the crops of these grasses at the time of flowering is considerable.

V. *Alopecurus alpinus*. Engl. Bot. 1126.
Alpine fox-tail grass. Nat. of Scotland.

At the time of flowering, the produce from a sandy loam with a small portion of manure, is—

		oz.	or lbs. per acre.
Grass, 8 oz. The produce per acre		87120	0= 5445 5 0
60 dr. of grass weigh when dry	16 dr.	23232	0= 1452 0 0
The produce of the space, ditto	34 2/16		
The weight lost by the produce of one acre in drying			3993 5 0
64 dr. of grass afford of nutritive matter	1 dr.	1361	4= 85 1 4
The produce of the space, ditto	2		

VI. *Poa alpina*. Engl. Bot. 1003. Flor. Dan. 107.
Alpine meadow grass. Nat. of Scotland.

At the time of flowering, the produce from a light sandy loam is—

Grass, 8 oz. The produce per acre	87120	0= 5445	0 0
64 dr. of grass afford of nutritive matter	1.2 dr.	2041 14	127 9 14

VII. *Avena pubescens*. Engl. Bot. 1640. Host. G. A. ii. t. 50.
Downy oat-grass. Nat. of Britain.

At the time of flowering, the produce from a rich randy soil is—

Grass, 23 oz. The produce per acre	250470	0=15654	6 0
80 dr. of grass weigh when dry	30 dr.	93926	0= 5870 6 4
The produce of the space, ditto	138 dr.		
The weight lost by the produce of one acre in drying			9783 15 12
64 dr. of grass afford of nutritive matter	1.2 dr.	5870	0= 366 14 6
The produce of the space, ditto	8.2 2/16		

At the time the seed is ripe, the produce is—

Grass 10 oz. The produce per acre	108900	0= 6806	4 0
80 dr. of grass weigh when dry	16 dr.	21780	0= 1361 4 0
The produce of the space, ditto	32		
The weight lost by the produce of one acre in drying			5545 0 0
64 dr. of grass afford of nutritive matter	2 dr.	3403	2= 212 11 0
The produce of the space, ditto	5		
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, being more than half of its value			154 6 3

The proportional value which the grass at the time of flowering bears to that at the time the seed is ripe, is as 6 to 8.

The produce of latter-math is—

		oz.	or lbs. per acre.
Grass, 10 oz. The produce per acre		108900	0= 6806 4 0
64 dr. of grass afford of nutritive matter	2 dr.	3403	2= 212 11 0

The proportional value which the grass at the time of flowering bears to that of the latter-math, is as 6 to 8. The grass of the seed-crop, and that of the latter-math, are of equal value.

The downy hairs which cover the surface of the leaves of this grass, when growing on poor light soils, almost entirely disappear when it is cultivated on a richer soil. It possesses several good qualities which recommend it to particular notice; it is hardy, early, and more productive than many others which affect similar soils and situations. Its growth after being cropped is tolerably rapid, although it does not attain to a great length if left growing: like the *Poa pratensis*, it sends forth flower-stalks but once in a season, and it appears well calculated for permanent pasture on rich light soils.

VIII. *Poa pratensis*. Curt. Lond. Engl. Bot. 1073.
Smooth-stalked meadow grass. Nat. of Britain.

At the time of flowering, the produce from a mixture of bog-earth and clay is—

Grass, 15 oz. The produce per acre	163350	0=10209	6 0
80 dr. of grass weigh when dry	22.2 dr.	45942	3= 2871 6 3
The produce of the space, ditto	67.2		
The weight lost by the produce of one acre in drying			7337 15 13
34 dr. of grass afford of nutritive matter	1.3 dr.	4466	9= 279 2 9
The produce of the space, ditto	6.2 1/16		

At the time the seed is ripe, the produce is—

Grass, 12·8 oz. The produce per acre	136125	0= 8507	13 0
80 dr. of grass weigh when dry	32 dr.	5445	0= 3403 2 0
The produce of the space, ditto	80		
The weight lost by the produce of one acre in drying			5104 11 0
64 dr. of grass afford of nutritive matter	1.2 dr.	3190	6= 199 6 0
The produce of the space, ditto	4.2 3/16		
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, being nearly one-fourth of its value			79 12 9

The produce of latter-math is—

Grass, 6 oz. The produce per acre	65340	0= 4083	12 0
64 dr. of grass afford of nutritive matter	1.3 dr.	1786 10=	111 10 0

The proportional value in which the grass of the latter-math exceeds that of the flowering crop, is as 6 to 7. The grass of the seed-crop and that of the latter-math are of equal value.

This grass is, therefore, of least value at the time the seed is ripe; a loss of more than one-

fourth of the value of the whole crop is sustained if it is not cut till that period: the straws are then dry, and the root-leaves in a sickly decaying state; those of the latter-math, on the contrary, are luxuriant and healthy. This species sends forth flower-stalks but once in a season; and these being the most valuable part of the plant for the purpose of hay, it will, from this circumstance, and the superior value of the grass of the latter-math compared to that of the seed-crop, appear well adapted for permanent pasture.

IX. *Poa cærulea.*—Var. *Poa pratensis.* Engl. Bot. 1004.

Poa subcærulea. Short bluish meadow-grass. Nat. of Britain. H. Kew. 1—155 Poa humilis.

At the time of flowering, the produce from a soil of the like nature as the preceding is—

	oz.		or lbs. per acre.		
Grass, 11 oz. The produce per acre	119790	0=	7486	14	0
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto 5·2	3743	7=	233	15	0
80 dr. of grass weigh when dry 24 The produce of the space, ditto 52·3 3/16	35937	0=	2246	1	0
The weight lost by the produce of one acre in drying			5240	13	0

If the produce of this variety be compared with that of the preceding one, it will be found less; nor does it seem to possess any superior excellence. The superior nutritive power does not make up for the deficiency of produce by 80 lbs. of nutritive matter per acre.

X. *Festuca hordiformis.* Poa hordiformis. H. Cant.

Barley-like fescue grass. Nat. of Hungary.

At the time of flowering, the produce from a sandy soil, with manure, is—

Grass, 20 oz. The produce per acre	217800	0=	13612	8	0
80 dr. of grass weigh when dry 24 dr. The produce of the space, ditto 96	65340	0=	4083	12	0
The weight lost by the produce of one acre in drying			9528	12	0
64 dr. of grass afford of nutritive matter 2·1 dr. The produce of the space, ditto 11·1	7657	0=	478	9	0

This is rather an early grass, though later than any of the preceding species; its foliage is very fine, resembling the *F. duriuscula*, to which it seems nearly allied, differing only in the length of the awns, and the glaucous color of the whole plant. The considerable produce it affords, and the nutritive powers it appears to possess, joined to its early growth, are qualities which strongly recommend it to further trial.

XI. *Poa trivialis.* Curt. Lond. Engl. Bot. 1072. Host. G. A. ii. t. 62.

Roughish meadow-grass. Nat. of Britain.

At the time of flowering, the produce from a light brown loam, with manure, is—

	oz.		or lbs. per acre		
Grass, 11 oz. The produce per acre	119790	0=	7486	14	0
80 dr. of grass weigh when dry 24 dr. The produce of the space, ditto 45 3/16	35937	0=	2246	1	0
The weight lost by the produce of one acre in drying			5240	13	0
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto 5.2	3743	7=	233	15	7

At the time the seed is ripe, the produce is—

Grass, 11·8 oz. The produce per acre	125235	0=	7827	3	0
80 dr. of grass weigh when dry 36 dr. The produce of the space, ditto 82.3 3/16	56355	12=	3522	3	12
The weight lost by the produce of one acre in drying			4304	15	4
64 dr. of grass afford of nutritive matter 2.3 dr. The produce of the space, ditto 7.3 3/5	5381	3=	336	5	3
The weight of nutritive matter which is lost by taking the crop at the time of flowering, exceeding one-fourth of its value			102	5	12

The proportional value in which the grass of the seed-crop exceeds that at the time of flowering, is as 8 to 11.

The produce of the latter-math is—

Grass, 7 oz. The produce per acre	76230	0=	4764	6	0
64 dr. of grass afford of nutritive matter 3 dr.	3573	4=	223	5	4

The proportional value by which the grass of the latter-math exceeds that of the flowering crop, is as 8 to 12, and that of the seed-crop as 11 to 12.

Here, then, is a satisfactory proof of the superior value of the crop at the time the seed is ripe, and of the consequent loss sustained by taking it when in flower; the produce of each crop being nearly equal. The deficiency of hay in the flowering crop, in proportion to that of the seed-crop, is very striking. Its superior produce, the highly nutritive powers which the grass seems to possess, and the season in which it arrives at perfection, are merits which distinguish it as one of the most valuable of those grasses which affect moist rich soils and sheltered situations; but on dry exposed situations it is altogether inconsiderable: it yearly diminishes, and ultimately dies off, not unfrequently in the space of four or five years.

XII. *Festuca glauca.* Curtis.

Glaucous fescue-grass. Nat. of Britain.

At the time the seed is ripe, the produce from a brown loam is—

Grass, 14 oz. The produce per acre	152460	0=	9528	12	0
80 dr. of grass weigh when dry 32 dr. The produce of the space, ditto 89.2 1/16·2/32	60984	0=	3811	8	0
The weight lost by the produce of one acre in drying			5717	4	0
64 dr. of grass afford of nutritive matter 1.2 dr. The produce of the space, ditto 5.1	2573	4=	223	5	4

At the time of flowering, the produce is—

	oz.		or lbs. per acre.		
Grass, 14 oz. The produce per acre . .	152460	0=	9528	12	0
80 dr. of grass weigh when dry . . 32 dr. The produce of the space, ditto . . 89.2⅔	60984	0=	4811	8	0
The weight lost by the produce of one acre in drying . .			5717	4	0
64 dr. of grass afford of nutritive matter 3 dr. The produce of the space, ditto . . 10.2	7146	9=	446	10	9
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, being half of the value of the crop . . .			223	5	5

The proportional value by which the grass at the time of flowering exceeds that at the time the seed is ripe, is as 6 to 12.

The proportional difference in the value of the flowering and seed crops of this grass is directly the reverse of that of the preceding species, and affords another strong proof of the value of the straws in grass which is intended for hay. The staws at the time of flowering are of a very succulent nature; but from that period till the seed be perfected, they gradually become dry and wiry. Nor do the root-leaves sensibly increase in number or in size, but a total suspension of increase appears in every part of the plant, the roots and seed-vessels excepted. The straws of the *Poa trivialis* are, on the contrary, at the time of flowering, weak and tender; but as they advance towards the period of ripening the seed, they become firm and succulent: after that period, however, they rapidly dry up, and appear little better than a mere dead substance.

XIII. *Festuca glabra.* Wither. B. ii. p. 154.
Smooth fescue-grass. Nat. of Scotland.

At the time of flowering, the produce from a clayey loam with manure is—

Grass, 21 oz. The produce per acre . .	228690	0=	14293	0	0
80 dr. of grass weigh when dry . 32 dr. The produce of the space, ditto . 134.1 2/15	91476	0=	5717	4	0
The weight lost by the produce of one acre in drying . .			8576	14	0
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto . 10.2	7146	0=	446	10	0

At the time the seed is ripe, the produce is—

Grass, 14 oz. The produce per acre .	152460	0=	9528	12	0
80 dr. of grass weigh when dry . 32 dr. The produce of the space, ditto . 89.2⅔	60984	0=	3811	8	0
The weight lost by the produce of one acre in drying . .			5717	4	0
64 dr. of grass afford of nutritive matter 1.1 dr. The produce of the space, ditto . 4.1¼	2977	11=	186	1	11
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, exceeding half of its value .			260	9	0

The proportional value which the grass at the time the seed is ripe bears to that of the crop at the time of flowering, is as 5 to 8.

The produce of latter-math is—

	oz.		or lbs. per acre.		
Grass, 9 oz. The produce per acre . .	98010	0=	6125	10	0
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto . 1.0½ dr.	765	11=	47	13	0

The proportional value which the grass of the latter-math bears to that of the crop at the time of flowering is as 2 to 8, and to that of the crop at the time the seed is ripe is as 2 to 5.

The general appearance of this grass is very similar to that of the *Festuca duriuscula:* it is, however, specifically different, and inferior in many respects, which will be manifest on comparing their several produce with each other; but if it be compared with some others, now under general cultivation, the result is much in its favor, the soil which it affects being duly attended to. The *Anthoxanthum odoratum* being taken as an example, it appears that

Festuca glabra affords of nutritive matter—

	lbs. per acre.
From the crop at the time of flowering 446 / At the time the seed is ripe, ditto . 186	632
Anthoxanthum odoratum,	
At the time of flowering, ditto . 122 / At the time the seed is ripe, ditto . 311	433
The weight of nutritive matter which is afforded by the produce of one acre of the *Festuca glabra*, exceeding that of the *Anthoxanthum odoratum* in proportion nearly as 6 to 9 . .	199

XIV. *Festuca rubra.* Wither. B. ii. p. 153.
Purple fescue-grass. Nat. of Britain.

At the time of flowering, the produce from a light sandy soil is—

Grass, 15 oz. The produce per acre . .	163350	0=	10209	6	0
80 dr. of grass weigh when dry . . 34 dr. The produce of the space, ditto . . 102	56923	12=	3557	11	0
The weight lost by the produce of one acre in drying			6651	11	0
64 dr. of grass afford of nutritive matter 1.2 dr. The produce of the space, ditto . . 22 2/16	3828	8=	239	4	8

At the time the seed is ripe, the produce is—

Grass, 16 oz. The produce per acre . .	174240	0=	10890	0	0
80 dr. of grass weigh when dry . . 36 dr. The produce of the space, ditto . . 115 3/16	78408	0=	4900	8	0
The weight lost by the produce of one acre in drying			5989	8	0
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto . . 8	5445	0=	340	5	0
The weight of nutritive matter which is lost by taking the crop when the grass is in flower, being nearly one-third part of its value . .			101	0	8

The proportional value which the grass at the

time of flowering bears to that at the time the seed is ripe, is as 6 to 8.

This species is smaller in every respect than the preceding. The leaves are seldom more than from three to four inches in length; it affects a soil similar to that favorable to the growth of the *Festuca ovina*, for which it would be a profitable substitute, as will clearly appear on a comparison of their produce with each other.

The produce of latter-math is—

	oz.	or lbs. per acre.
Grass, 5 oz. The produce per acre	54450 0=	3403 2 0
64 dr. of grass afford of nutritive matter 1.2 dr.	1276 2=	79 12 0

The proportional value which the grass of the latter-math bears to that at the time the seed is ripe, is as 6 to 8, and is of equal value with the grass at the time of flowering.

XV. *Festuca ovina.* Engl. Bot. 585. Wither. B. ii. p. 152.

Sheep's fescue grass. Nat. of Britain.

At the time the seed is ripe, the produce is—

Grass, 8 oz. The produce per acre	87120 0=	5445 0 0
64 dr. of grass afford of nutritive matter 1.2 dr. / The produce of the space, ditto 3	2031 14=	127 9 0

The produce of latter-math is—

Grass, 5 oz. The produce per acre	54450 0=	3403 2 0
64 dr. of grass afford of nutritive matter 1.1 dr.	1063 7=	66 7 7

The dry weight of this species was not ascertained, because the smallness of the produce renders it entirely unfit for hay. If the nutritive powers of this species be compared with those of the preceding, the inferiority will appear thus:

Festuca ovina affords of	nutritive matter	1.2	2.3
Ditto	ditto	1.1	
Festuca rubra	ditto	2	3.2
Ditto	ditto	1.2	

The comparative degree of nourishment which the grass of the *Festuca rubra* affords exceeds therefore that afforded by the *F. ovina* in proportion as 11 to 14.

From the trial that is here detailed, it does not seem to possess the nutritive powers generally ascribed to it; it has the advantage of a fine foliage, and may, therefore, very probably, be better adapted to the masticating organs of sheep than the larger grasses, whose nutritive powers are shown to be greater: hence, on situations where it naturally grows, and as pasture for sheep, it may be inferior to few others. It possesses natural characters very distinct from *F. rubra.*

XVI. *Briza media.* Engl. Bot. 340. Host. G. A. ii. t. 29.

Common quaking-grass. Nat. of Britain.

At the time of flowering, the produce from a rich brown loam is—

Grass, 14 oz. The produce per acre	152460 0=	9528 12 0
80 dr. of grass weigh when dry 26 dr. / The produce of the space ditto $72.3\frac{1}{16}$	49549 8=	3096 13 8
The weight lost by the produce of one acre in drying	6431 14	8

	oz.	or lbs. per acre.
64 dr. of grass afford of nutritive matter 2.3 dr. / The produce of the space, ditto $9.2\frac{2}{16}$	6551 0=	409 7 0

At the time the seed is ripe, the produce is—

Grass, 14 oz. The produce per acre	152460 0=	9528 12 0
80 dr. of grass weigh when dry 28 dr. / The produce of the space, ditto $78.1\frac{3}{5}$	53362 0=	3335 1 0
The weight lost by the produce of one acre in drying	6183	11 0
64 dr. of grass afford of nutritive matter 3.1 dr. / The produce of the space, ditto $11.1\frac{1}{2}$	7742 1=	483 14 1
The weight of nutritive matter which is lost by taking the crop at the time of flowering, being nearly one-fourth part of its value	109	1 0

The proportional value which the grass at the time of flowering bears to that at the time the seed is ripe, is as 11 to 13.

The latter-math produce is—

Grass, 12 oz. The produce per acre	130680 0=	8167 8 0
64 dr. of grass afford of nutritive matter 2 dr.	483 12=	255 3 12

The proportional value in which the grass at the time of flowering exceeds that of the latter-math, is as 8 to 11; and the latter-math stands to that at the time the seed is ripe in proportion as 8 to 13.

The merits of this grass seem to demand notice: its nutritive powers are considerable, and its produce large when compared with others which affect a similar soil.

XVII. *Dactylis glomerata.* Engl. Bot. 335. Fl. Dan. 743.

Round-headed cock's-foot grass. Nat. of Britain. Wither. B. ii. p. 149.

At the time of flowering, the produce from a rich sandy loam is—

Grass, 41 oz. The produce per acre	446490 0=	27905 10 0
80 dr. of grass weigh when dry 34 dr. / The produce of the space, ditto $278\frac{4}{5}$	189758 4=	11859 14 4
The weight lost by the produce of one acre in drying	16045	11 12
64 dr of grass afford of nutritive matter 2.2 dr. / The produce of the space, ditto $25.2\frac{1}{2}$	17424 0=	1089 0 0

At the time the seed is ripe, the produce is—

Grass, 39 oz. The produce per acre	424710 0=	26544 6 0
80 dr. of grass weigh when dry 40 dr. / The produce of the space, ditto 312	21235 0=	13272 3 0
The weight lost by the produce of one acre	13272	3 0
64 dr. of grass afford of nutritive matter 3.2 dr. / The produce of the space, ditto $34.0\frac{1}{2}$	23226 5=	1451 10 0
The weight of nutritive matter which is gained by leaving the crop till the seed be ripe, being more than one-third part of its value, is	362	10 5

The proportional value which the grass at the time of flowering bears to that at the time the seed is ripe, is as 5 to 7, nearly.

The produce of latter-math is—

		oz.	or lbs. per acre.
Grass, 17 oz. 8 dr.	The produce per acre	190575	0=11910 15 0
64 dr. of grass afford of nutritive matter	1.2 dr.	4466	9= 281 10 9

The proportional value which the grass of the latter-math bears to that at the time of flowering is as 6 to 10; and to that at the time the seed is ripe, as 6 to 14. 64 dr. of the straws at the time of flowering afford of nutritive matter 1.2 dr. The leaves or latter-math, and the straws simply, are therefore of equal proportional value; a circumstance which will point out this grass to be more valuable for permanent pasture than for hay. The above details prove, that a loss of nearly one-third of the value of the crop is sustained if it is left till the period when the seed is ripe, though the proportional value of the grass at that time is greater, *i. e.* as 7 to 5. The produce does not increase if the grass is left growing after the period of flowering, but uniformly decreases; and the loss of latter-math, which (from the rapid growth of the foliage after the grass is cropped) is very considerable. These circumstances point out the necessity of keeping this grass closely cropped, either with the scythe or cattle, to reap the full benefit of its great merits.

XVIII. *Bromus tectorum.* Host. G. A. i. t. 15. Nodding panicled brome-grass. Nat. of Europe. Introduced 1776. H. K. i. 168.

At the time of flowering, the produce from a light sandy soil is—

Grass, 11 oz.	The produce per acre	119790	0= 7486	14 0
80 dr. of grass weigh when dry	42 dr.	62889	12= 3930	9 12
The produce of the space, ditto	92.1⅗			
The weight lost by the produce of one acre in drying			3556	4 4
64 dr. of grass afford of nutritive matter	3 dr.	5615	2= 350	15 2
The produce of the space, ditto	8.1			

This species, being strictly annual, affords no latter-math, which renders it comparatively of little value.

XIX. *Festuca cambrica.* Hudson. W. B. ii. p. 155. Nat. of Britain.

At the time of flowering, the produce from a light sandy soil is—

Grass, 10 oz.	The produce per acre	108900	0= 6806	4 0
80 dr. of grass weigh when dry	34 dr.	46282	8= 2892	10 8
The produce of the space, ditto	68			
The weight lost by the produce of one acre in drying			3913	9 8
64 dr. of grass afford of nutritive matter	2.1 dr.	3828	8= 239	4 8
The produce of the space, ditto	5.2½			

This species is nearly allied to the *Festuca ovina*, from which it differs little, except that it is larger in every respect. The produce, and the nutritive matter which it affords, will be found superior to those given by the *F. ovina*, if they are brought into comparison.

XX. *Bromus diandrus.* Curt. Lond. Eng. Bot. 1006 Nat. of Britain.

At the time the grass is ripe in flower, the produce from a rich brown loam is—

		oz.	or lbs. per acre.
Grass, 30 oz.	The produce per acre	326700	0=20418 12 0
80 dr. of grass weigh when dry	34 dr.	138847	8= 8677 15 0
The produce of the space, ditto	204		
The weight lost by the produce of one acre in drying			11740 13 0
64 dr. of grass afford of nutritive matter	3 dr.	15314	1= 957 2 1
The produce of the space, ditto	22.2		

This species, like the preceding, is strictly annual; the above is therefore the produce for one year, which, if compared with that of the least productive of the perennial grasses, will be found inferior, and it must consequently be regarded as unworthy of culture.

XXI. *Poa angustifolia.* With. ii. p. 142. Narrow-leaved meadow-grass. Nat. of Britain.

At the time of flowering, the produce from a brown loam is—

Grass, 27 oz.	The produce per acre	294030	0=18376	14 0
80 dr. of grass weigh when dry	34 dr.	124962	12= 7810	2 12
The produce of the space, ditto	183.2⅖			
The weight lost by the produce of one acre in drying			10566	11 4
64 dr. of grass afford of nutritive matter	5 dr.	22886	11= 1430	6 11
The produce of the space, ditto	33.3			

At the time the seed is ripe the produce is—

Grass, 14 oz.	The produce per acre	152460	0=9528	12 0
80 dr. of grass weigh when dry	32 dr.	60984	0= 3811	8 0
The produce of the space, ditto	89.2⅖			
The weight lost by the produce of one acre in drying			5717	4 0
64 dr. of grass afford of nutritive matter	5.1 dr.	12506	7= 701	6 7
The produce of the space, ditto	18.1½			
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, exceeding one-third part of its value			649	0 4

In the early growth of the leaves of this species of *Poa* there is a striking proof that early flowering in grasses is not always connected with the most abundant early produce of leaves. In this respect all the species which have already come under examination are greatly inferior to that now spoken of. Before the middle of April the leaves attain to the length of more than twelve inches, and are soft and succulent; in May, however, when the flower-stalks make their appearance, it is subject to the disease termed rust,

which affects the whole plant; the consequence of which is manifest in the great deficiency of produce in the crop at the time the seed is ripe, being one-half less than at the time of the flowering of the grass. Though this disease begins in the straws, the leaves suffer most from its effects, being at the time the seed is ripe completely dried up: the straws, therefore, constitute the principal part of the crop for mowing, and they contain more nutritive matter in proportion than the leaves. This grass is evidently most valuable for permanent pasture, for which, in consequence of its superior, rapid, and early growth, and the disease beginning at the straws, nature seems to have designed it. The grasses which approach nearest to this in respect of early produce of leaves, are the *Poa fertilis*, *Dactylis glomerata*, *Phleum pratense*, *Alopecurus pratensis*, *Avena eliator*, and *Bromus littoreus*, all grasses of a coarser kind.

XXII. *Avena eliator*. Curtis, 112. Engl. Bot. 813.—Holcus avenaceus.

Tall oat-grass. Nat. of Britain.

At the time the seed is ripe, the produce is—

	oz.		or lbs. per acre.	
Grass, 24 oz. The produce per acre	261360	0=	16335	0 0
80 dr. of grass weigh when dry . . 28 dr. The produce of the space, ditto . . 134.1 3/5	91475	14=	5717	3 14
The weight lost by the produce of one acre in drying			10617	12 2
64 dr. of grass afford of nutritive matter 1 dr. The produce of the space, ditto . . 6	4083	12=	255	3 12

The produce of latter-math is—

Grass 20 oz. The produce per acre	217800	0=	13612	8 0
64 dr. of grass afford of nutritive matter 1.1 dr.	4253	14=	265	13 14
The weight of nutritive matter which is afforded by the crop of the latter-math exceeding that afforded by the grass of the seed crop in proportion nearly as 26 to 25			10	9 2

This grass sends forth flower-straws during the whole season: the latter-math contains nearly an equal number with the flowering crop. It is subject to the rust, but the disease does not make its appearance till after the period of flowering: it affects the whole plant, and at the time the seed is ripe the leaves and straws are withered and dry. This accounts for the superior value of the latter-math over the seed crop, and points out the propriety of taking the crop when the grass is in flower.

XXIII. *Poa eliator*. Curtis, 50.

Tall meadow-grass. Nat. of Scotland.

At the time of flowering, the produce from a rich clayey loam is—

Grass, 18 oz. The produce per acre	196020	0=	12251	4 0
80 dr. of grass weigh when dry . . 28 dr. The produce of the space, ditto . . 100.3 2/16	60607	0=	4287	15 0
64 dr. of grass afford of nutritive matter 3.2 The produce of the space, ditto . 15.3	10719	13=	669	15 13
The weight lost by the produce of one acre in drying			3617	15 3

The botanical characters of this grass are almost the same as those of the *Avena eliator*, differing in the want of the awns only. It has the essential character of the *Holci* (Florets male, and hermaphrodite: Calyx husks two valved, with two florets,) and since the *Avena eliator* is now referred to that genus, this may with certainty be considered a variety of it.

XXIV. *Festuca duriuscula*. Engl. Bot. 470, W. B. ii. p. 153.

Hard fescue-grass. Nat. of Britain.

At the time of flowering, the produce from a light sandy loam is—

Grass, 27 oz. The produce per acre	294030	0=	18376	14 0
80 dr. of grass weigh when dry . . 36 dr. The produce of the space, ditto . . 194.1 3/5	132313	8=	8269	9 0
The weight lost by the produce of one acre in drying			10106	4 8
64 dr. of grass afford of nutritive matter 3.2 dr. The produce of the space, ditto . . 23.2 1/2	16079	12=	1004	15 12

At the time the seed is ripe, the produce is—

Grass, 28 oz. The produce per acre	304920	0=	19075	8 0
80 dr. of grass weigh when dry - - 36 dr. The produce of the space, ditto - - 201.2 2/5	137214	0=	8575	14 0
The weight lost by the produce of one acre in drying			10481	10 0
64 dr. of grass afford of nutritive matter 1·2 dr. The produce of the space, ditto - - 10.2 dr.	7146	9=	446	10 9
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe exceeding one-half of its value			558	5 3

The proportional value which the grass, at the time the seed is ripe, bears to that at the time of flowering, is as 6 to 14, nearly.

The produce of latter-math is

Grass, 15 oz. The produce per acre	163350	0=	10209	6 0
64 dr. of grass afford of nutritive matter 1.1 dr.	3190	4=	199	6 4

The proportional value which the grass of the lattar-math bears to that at the time of flowering, is as 5 to 14, and to that at the time the seed is ripe, 5 to 6.

The above particulars will confirm the favorable opinion which was given of this grass when speaking of the *festuca hordiformis*, and *F. glabra*. Its produce in the spring is not very great, but of the finest quality, and at the time of flowering is considerable. If it be compared with those affecting similar soils, such as *Poa pratensis*, *Festuca ovina*, &c., either considered as a grass for hay, or permanent pasture, it will be found of greater value.

XXV. *Bromus erectus*. Engl. Bot. 471. Host. G. A.

Upright perennial brome-grass. Nat. of Britain.

At the time of flowering, the produce from a rich sandy soil is—

	oz.	or lbs. per acre.
Grass, 19 oz. The produce per acre	206910 0	= 12931 14 0
80 dr. of grass weigh when dry 36 dr. The produce of the space, ditto 136.3⅓	93109 8	= 5819 5 8
The weight lost by the produce of one acre in drying	7112 8	8
64 dr. of grass afford of nutritive matter 2.3 dr. The produce of the space, ditto 13.0¼	8890 10	= 555 10 10

XXVI. *Milium effusum.* Curt. Lond. Engl. Bot. 1106.

Common millet-grass. Nat. of Britain.

At the time of flowering, the produce from a light sandy soil is—

Grass 11 oz. 8 dr. The produce per acre	196020 0	= 12251 4 0
80 dr. of grass weigh when dry 31 dr. The produce of the space, ditto 111.2⅔	75957 12	= 4747 5 12
64 dr. of grass afford of nutritive matter 1.3 The produce of the space, ditto 7.3¾	5359 14	= 334 15 14

This species in its natural state seems confined to woods as its place of growth; but the trial that is here mentioned, confirms the opinion that it will grow and thrive in open exposed situations. It is remarkable for the lightness of the produce, in proportion to its bulk. It produces foliage early in the spring, in considerable abundance; but its nutritive powers appear comparatively little.

XXVII. *Festuca pratensis.* Engl. Bot. 1592. C. Lond.

Meadow fescue-grass. Nat. of Britain.

At the time of flowering, the produce from a bog soil, with coal ashes for manure, is—

Grass, 20 oz. The produce per acre	217800 0	= 13612 8 0
80 dr. of grass weigh when dry 38 dr. The produce of the space, ditto 152	103455 8	= 6465 15 0
The weight lost by the produce of one acre in drying	7146 9	0
64 dr. of grass afford of nutritive matter 4.2 dr. The produce of the space, ditto 22.2	15314 1	= 957 2 1

At the time the seed is ripe, the produce is—

Grass, 28 oz. The produce per acre	304920 0	= 19057 8 0
80 dr. of grass weigh when dry 32 dr. The produce of the space, ditto 179.0¼	121968 0	= 7623 0 0
The weight lost by the produce of one acre in drying	11434 8	8
64 dr. of grass afford of nutritive matter 1.2 dr. The produce of the space, ditto 10.2	7146 9	= 446 10 9
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe exceeding one half of its value	510 7	8

The value of the grass at the time the seed is ripe, is to that of the grass at the time of flowering, as 6 to 18.

The loss which is sustained by leaving the crop of this grass till the seed be ripe is very great. That it loses more of its weight in drying at this stage of growth, than at the time of flowering, perfectly agrees with the deficiency of nutritive matter in the seed crop, in proportion to that in the flowering crop: the straws being succulent in the former, they constitute the greatest part of the weight; but in the latter they are comparatively withered and dry; consequently the leaves constitute the greatest part of the weight. It may be observed here, that there is a great difference between straws or leaves that have been dried after they were cut in a succulent state, and those which are dried (if I may so express it) by nature while growing. The former retain all their nutritive powers; but the latter, if completely dry, very little, if any.

XXVIII. *Lolium perenne.* Engl. Bot. 315. Flo. Dan. 747.

Perennial rye-grass. Nat. of Britain.

At the time of flowering, the produce from a rich brown loam is—

	oz.	or lbs. per acre.
Grass, 11 oz. 8 dr. The produce per acre	125235 0	= 7827 3 0
80 dr. of grass weigh when dry 34 dr The produce of the space, ditto 78 4/11	53156 13	= 3322 4 13
The weight lost by the produce of one acre in drying	4494 14	3
64 dr. of grass afford of nutritive matter 2.2 dr. The produce of the space, ditto 7.0¾	4891 15	= 305 11 15

At the time the seed is ripe, the produce is—

Grass, 22 oz. The produce per acre	239580 0	= 14973 12 0
80 dr. of grass weigh when dry 24 dr. The produce of the space, ditto 105.2⅔	71874 0	= 4492 2 0
The weight lost by the produce of one acre in drying	10481 10	0
64 dr. of grass afford of nutritive matter 2.3 dr. The produce of the space, ditto 15.0 3/11	10294 7	= 643 6 7
The weight of nutritive matter which is lost by taking the crop at the time of flowering exceeding nearly one half of its value	337 8	8

The proportional value which the grass at the time of flowering bears to that at the time the seed is ripe is as 10 to 11.

The produce of the latter-math is—

Grass, 5 oz. The produce per acre	54450 0	= 3403 2 0
64 dr. of grass afford of nutritive matter 1 dr.	850 12	= 53 2 12

The proportional value which the grass of the latter-math bears to that at the time of flowering is as 4 to 10, and to that at the time the seed is ripe, as 4 to 11.

XXIX. *Poa maritima.* Engl. Bot. 1140.
Sea meadow-grass. Nat. of Britain.

At the time of flowering, the produce from a light brown loam is—

	oz.		or lbs. per acre.	
Grass, 18 oz. The produce per acre . .	196020	0=	12251	4 0
80 dr. of grass weigh when dry . . 32 dr. The produce of the space, ditto . . 115.$\frac{1}{5}$	78408	0=	900	0 0
The weight lost by the produce of one acre in drying . .			7350	4 0
64 dr. of grass afford of nutritive matter 4.2 dr. The produce of the space, ditto . . 20.1	13782	0=	861	6 0

The produce of the latter-math is—

Grass, 18 oz. The produce per acre . .	196020	0=	12251	4 0
64 dr. of grass afford of nutritive matter 1 dr.	3062	13=	191	6 31

The proportional value which the grass of the latter-math bears to that at the time of flowering is as 4 to 18.

XXX. *Cynosurus cristatus.* Engl. Bot. 316. Host. G. A. ii. t. 96.
Crested dog's-tail grass.

At the time of flowering, the produce from the brown loam, with manure, is—

Grass, 9 oz. The produce per acre . . .	98010	0=	6125	10 0
80 dr. of grass weigh when dry . . 24 dr. The produce of the space, ditto . . 43	29403	0=	1837	11 0
The weight lost by the produce of one acre in drying . .			4287	15 0
64 dr. of grass afford of nutritive matter 4.1 dr. The produce of the space, ditto . . 9.2$\frac{1}{16}$	6508	7=	406	12 7

At the time the seed is ripe, the produce is—

Grass, 18 oz. The produce per acre . .	196020	0=	12251	4 0
80 dr. of grass weigh when dry . . 32 dr. The produce of the space, ditto . . 115.0$\frac{3}{10}$	78408	0=	4900	0 0
The weight lost by the produce of one acre in drying . .			7350	12 0
64 dr. of grass afford of nutritive matter 2.2 dr. The produce of the space, ditto . . 11.1	7657	0=	478	9 0
The weight of nutritive matter which is lost by taking the crop at the time of flowering, exceeding one-sixth of its value			71	12 9

XXXI. *Avena pratensis.* Engl. Bot. 1204. Fl. Dan. 1083.
Meadow oat-grass. Nat. of Britain.

At the time of flowering, the produce from a rich sandy loam is—

Grass, 10 oz. The produce per acre . . .	108900	0=	6806	4 0
80 dr. of grass weigh when dry . . 22 dr. The produce of the space, ditto . . 44	29947	8=	1871	11 8
The weight lost by the produce of one acre in drying			4934	8 8

	oz.		or lbs. per acre.	
64 dr. of grass afford of nutritive matter 2.1 dr. The produce of the space, ditto . . 5.2$\frac{1}{2}$	3828	8=	239	4 8

At the time the seed is ripe, the produce is—

Grass, 14 oz. The produce per acre . .	152460	0=	9528	12 0
80 dr. of grass weigh when dry . . 24 dr. The produce of the space, ditto . . 67.0$\frac{4}{5}$	45738	0=	2858	10 0
The weight lost by the produce of one acre in drying			6670	2 0
64 dr. of grass afford of nutritive matter 1 dr. The produce of the space, ditto . . 3.2	2382	3=	148	14 3
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, exceeding one-third part of its value			90	6 0

The proportional value which the crops, at the time the seed is ripe, bear to that at the time of flowering, is as 4 to 9.

XXXII. *Bromus multiflorus.* Engl. Bot. 1884. Host. G. A. i. t. 11.
Many-flowering brome-grass. Nat. of Britain.

At the time of flowering, the produce from a clayey loam is—

Grass, 33 oz. The produce per acre .	359370	0=	22460	10 0
80 dr. of grass weigh when dry . 44 dr. The produce of the space, ditto . . 290.0$\frac{2}{5}$	197653	8=	12353	5 8
The weight lost by the produce of one acre in drying . . .			10107	4 8
64 dr. of grass afford of nutritive matter 5 dr. The produce of the space, ditto . 41.1	28075	12=	1754	11 12

This species is annual, and no valuable properties have as yet been discovered in the seed. It is only noticed on account of its being frequently found in poor grass lands, and sometimes in meadows. It appears from the above particulars to possess nutritive powers equal to some of the best perennial kinds, if taken when in flower; but if left till the seed be ripe (which, from its early growth, is frequently the case), the crop is comparatively of no value, the leaves and straws being then completely dry.

XXXIII. *Festuca loliacea.* Curt. Lond. Engl. Bot. 1821.
Spiked fescue-grass. Nat. of Britain.

At the time of flowering, the produce from a brown rich loam is—

Grass, 24 oz. The produce per acre . .	261360	0=	16335	0 0
80 dr. of grass weigh when dry . 35 dr. The produce of the space, ditto . 168	114345	0=	7146	9 0
The weight lost by the produce of one acre in drying . .			9188	7 0
64 dr. of grass afford of nutritive matter 3 dr. The produce of the space, ditto . 18	12251	4=	765	11 0

At the time the seed is ripe, the produce is—

	oz.	or lbs. per acre.
Grass, 16 oz. The produce per acre	174240	0=10890 0 0
80 dr. of grass weigh when dry . 33 dr. The produce of the space, ditto . $105\frac{3}{5}$	71874	0= 4492 2 0
The weight lost by the produce of one acre in drying		6397 14 0
64 dr. of grass afford of nutritive matter 3.1 dr. The produce of the space, ditto . 13	8848	2= 553 2 0

The latter-math produce is—

Grass, 5 oz. The produce per acre	54450	0= 3403 2 0
64 dr. of grass afford of nutritive matter 1.1 dr.	1063	7= 66 7 7
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, exceeding one-fourth part of its value		212 11 0

The proportional value which the grass, at the time of flowering, bears to that at the time the seed is ripe, is as 12 to 13; and the value of the latter-math stands in proportion to that of the crop at the time of flowering, as 5 to 12, and to that of the crop taken at the time the seed is ripe, as 5 to 13.

This species of fescue greatly resembles the rye-grass, in habit and place of growth; it has excellencies which make it greatly superior to that grass, for the purposes of either hay or permanent pasture. This species seems to improve in produce in proportion to its age, which is directly the reverse of the *Lolium perenne*.

XXXIV. *Poa cristata.* Host. G. A. ii. t. 75.—Aira Cristata. Engl. Bot. 648.

Crested meadow-grass. Nat. of Britain.

At the time of flowering, the produce from a sandy loam is—

Grass, 16 oz. The produce per acre	174240	0= 10890 0 0
80 dr. of grass weigh when dry . 36 dr. The produce of the space, ditto . $115\frac{3}{16}$	7848	0= 4900 8 0
The weight lost by the produce of one acre in drying		5989 8 0
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto . 8	5445	0= 340 5 0

The produce of this species, and the nutritive matter that it affords, are equal to those of the *Festuca ovina* at the time the seed is ripe: they equally delight in dry soils. The greater bulk of grass in proportion to the weight, with the comparative coarseness of the foliage, render the *Poa cristata* inferior to the *Festuca ovina*.

XXXV. *Festuca myurus.* Engl. Bot. 1412. Host. G. A. ii. t. 93.

Wall fescue-grass. Nat. of Britain.

At the time of flowering, the produce from a light sandy soil is—

Grass, 14 oz. The produce per acre	152460	0= 9528 12 0
80 dr. of grass weigh when dry . 24 dr. The produce of the space, ditto . $67\frac{2}{16}$	45738	0= 2858 10 0
The weight lost by the produce of one acre in drying		6670 2 0
64 dr. of grass afford of nutritive matter 1·2 dr. The produce of the space, ditto . 5·1	8573	4= 223 5 4

This species is strictly annual; it is likewise subject to the rust; and the above being its whole produce for one year, it ranks as a very inferior grass.

XXXVI. *Aira flexuosa.* Engl. Bot. 1519. Host. G. A. ii. t. 43.

Waved mountain hair-grass. Nat. of Britain.

At the time of flowering, the produce from a heath soil is—

Grass, 12 oz. The produce per acre	130680	0= 8167 8 0
80 dr. of grass weigh when dry . 31 dr. The produce of the space, ditto . $74\frac{3}{5}$	50638	0= 3164 14 8
The weight lost by the produce of one acre in drying		5002 9 8
64 dr. of grass afford of nutritive matter 1.2 dr. The produce of the space, ditto . 4.2	3062	13= 191 6 13

XXXVII. *Hordeum bulbosum.* Hort. Kew. i. p. 179.

Bulbous barley-grass. Nat. of Italy and the Levant. Introduced 1770, by Mons. Richard.

At the time of flowering, the produce from a clayey loam, with manure, is—

Grass, 35 oz. The produce per acre	381150	0=23821 0 0
80 dr. of grass weigh when dry . 93 dr. The produce of the space, ditto . 231	157224	0= 9826 8 6
The weight lost by the produce of one acre in drying		13994 7 10
64 dr. of grass afford of nutritive matter 3.2 dr. The produce of the space, ditto . $30.2\frac{2}{4}$	20844	2= 1302 12 2

XXXVIII. *Festuca calamaria.* Engl. Bot. 1005. Reed-like fescue-grass. Nat. of Britain.

At the time of flowering, the produce from a clayey loam is—

Grass, 80 oz. The produce per acre	871200	0= 54450 0 0
80 dr. of grass weigh when dry . 28 dr. The produce of the space, ditto . 448	304920	0= 19057 8 0
The weight lost by the produce of one acre in drying		35392 8 0
64 dr. of grass afford of nutritive matter 4.2 dr. The produce of the space, ditto . 90	61256	4= 3828 8 4

At the time the seed is ripe, the produce is—

Grass, 75 oz. The produce per acre	816750	0= 51046 14 0
80 dr. of grass weigh when dry . 19 dr. The produce of the space, ditto . 283	193978	2= 12123 10 0

The weight lost by the produce of one acre in drying			38223	4 0
	oz.		or lbs. per acre.	
64 dr. of grass afford of nutritive matter 3 dr. / The produce of the space, ditto . . 56.1	38285	2=	2392	13 2
The weight of nutritive matter which is lost by leaving the crop till the seed is ripe, being nearly one-third part of its value			1435	11 2

The proportional value which the grass at the time the seed is ripe, bears to that at the time of flowering, is as 12 to 18.

This grass, as has already been remarked, produces a fine early foliage in the spring. The produce is very great, and its nutritive powers are considerable. It appears, from the above particulars, to be best adapted for hay. A very singular disease attacks, and sometimes nearly destroys, the seed of this grass: the cause of this disease seems to be unknown; it is denominated Clavus by some; it appears by the seed swelling to three times its usual size in length and thickness, and the want of the carcle. Dr. Willdenow describes two distinct species of it: 1st, the simple clavus, which is mealy and of a dark color, without any smell or taste; 2dly, the malignant clavus, which is violet blue, or blackish, and internally too has a bluish color, a fœtid smell, and a sharp pungent taste. Bread made from grain affected with this last species is of a bluish color; when eaten, produces cramps and giddiness.

XXXIX. *Bromus littoreus.* Host. G. A. P. vii. t. 8.

Sea-side brome-grass. Nat. of Germany: grows on the banks of the Danube and other rivers.

At the time of flowering, the produce from a clayey loam is—

Grass, 61 oz. The produce per acre . .	664290	0=	41518	2 0
80 dr. of grass weigh when dry . . 41 dr. / The produce of the space, ditto . . 500.$\frac{2}{16}$	340448	10=	21278	0 10
The weight lost by the produce of one acre in drying . .			20540	1 6
64 dr. of grass afford of nutritive matter 1.2 dr. / The produce of the space, ditto . 22.3$\frac{1}{2}$	15567	4=	973	1 4

At the time the seed is ripe, the produce is—

Grass, 56 oz. The produce per acre . .	609840	0=	38115	0 0
80 dr. of grass weigh when dry . . 32 dr. / The produce of the space, ditto . . 358$\frac{1}{6}$	243936	0=	15246	0 0
The weight lost by the produce of one acre in drying . .			22869	0 0
64 dr. of grass afford of nutritive matter 3·2 dr. / The produce of the space, ditto . . 196	33950	0=	2084	6 10
The weight of nutritive matter which is lost by taking the crop at the time of flowering, exceeding one-half of its value			1111	5 6

The proportional value which the grass, at the time of flowering, bears to that at the time the seed is ripe, is as 6 to 14.

This species greatly resembles the preceding in habit and manner of growth, but is inferior to it in value, which is evident from the deficiency of its produce, and of the nutritive matter afforded by it. The whole plant is likewise coarser, and of greater bulk in proportion to its weight. The seed is affected with the same disease which destroys that of the former species.

XL. *Festuca eliator.* Engl. Bot. 1593. Host. G. A. ii. t. 79.

Tall fescue-grass. Nat. of Britain.

At the time of flowering, the produce from a black rich loam is—

	oz.		or lbs. per acre.	
Grass, 75 oz. The produce per acre . . .	816750	0=	51046	14 0
80 dr. of grass weigh when dry . . 28 dr. / The produce of the space, ditto . . 420	285862	1=	17866	6 8
The weight which is lost by the produce of one acre in drying .			33180	7 8
64 dr. of grass afford of nutritive matter 5 dr. / The produce of the space, ditto . . 93.3	63808	9=	3988	0 9

At the time the seed is ripe the produce is—

Grass 75 oz. The produce per acre . .	816750	0=	51046	4 0
80 dr. of grass weigh when dry . . 28 dr. / The produce of the space, ditto . . 420	285862	8=	17866	6 0
The weight lost by the produce of one acre in drying . . .			33180	7 8
64 dr. of grass afford of nutritive matter 3 dr. / The produce of the space, ditto . . 56.1	38285	2=	2392	13 2
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, exceeding one-third part of its value			1595	3 7

The proportional value which the grass, at the time the seed is ripe, bears to that at the time of flowering, is as 12 to 20.

The produce of the latter-math is—

Grass, 23 oz. The produce per acre . .	250470	0=	15654	6 0
64 dr. of grass afford of nutritive matter 4 dr.	15054	6=	978	6 6

The proportional value which the grass of the latter-math bears to that of the crop, is as 16 to 20; and to that at the time the seed is ripe, as 12 to 16 inverse.

This species of fescue is closely allied to the *Festuca pratensis*, from which it differs in little, except that it is larger in every respect. The produce is nearly three times that of the *F. pratensis*, and the nutritive powers of the grass are superior, in direct proportion, as 6 to 8.

XLI. *Nardus stricta.* Engl. Bot. 290. Host. G. A. ii. t. 4.

Upright mat-grass. Nat. of Britain.

At the time the seed is ripe, the produce is—

Grass, 9 oz. The produce per acre . .	98010	0=	6125	10 0

	oz.	or lbs. per acre.		
80 dr. of grass weigh when dry . . 32 dr. The produce of the space, ditto . 57.2⅔	39204	0=	2450	4 0
The weight lost by the produce of one acre in drying . . .			3675	6 0
64 dr. of grass afford of nutritive matter 2.1 dr. The produce of the space, ditto . 5.0⅕	3445	10=	215	5 10

XLII. *Triticum, Sp.*
Wheat-grass.

At the time of flowering, the produce from a rich randy loam is—

Grass, 18 oz. The produce per acre . .	196020	0=	12251	4 0
80 dr. of grass weigh when dry . . 32 dr. The produce of the space, ditto . . 115⅕	78408	0=	4900	8 0
The weight lost by the produce of one acre in drying . . .			7350	12 0
64 dr. of grass afford of nutritive matter 2.2 dr. The produce of the space, ditto . 11.1	7657	0=	478	9 0

XLIII. *Festuca fluitans.* Curt. Lond. Engl. Bot. 1520. Poa fluitans.
Floating fescue-grass. Nat. of Britain.

At the time of flowering, the produce from a strong tenacious clay is—

Grass, 20 oz. The produce per acre . .	217800	0=	13612	8 0
80 dr. of grass weigh when dry . . 24 dr. The produce of the space, ditto . . 96	65340	0=	4083	12 0
The weight lost by the produce of one acre in drying . . .			9528	12 0
64 dr. of grass afford of nutritive matter . 1.3 dr. The produce of the space, ditto . . 8.3	5955	0=	372	3 7

The above produce was taken from grass that had occupied the ground for four years, during which time it had increased every year; it therefore appears contrary to what some have supposed to be capable of being cultivated in perennial pastures.

XLIV. *Holcus lanatus.* Curt. Lond. Fl. Dan. 1811.
Meadow soft grass. Yorkshire grass. Nat. of Britain.

At the time of flowering, the produce from a strong clayey loam is—

Grass, 28 oz. The produce per acre . .	304920	0=	19057	8 0
80 dr. of grass weigh when dry . . 26 dr. The produce of the space, ditto . 157.2⅔	106585	14=	6661	9 14
The weight lost by the produce of one acre in drying . . .			12395	14 2
64 dr. of grass afford of nutritive matter . 4 dr. The produce of the space, ditto . . 28	19057	8=	1191	1 8

At the time the seed is ripe, the produce is—

Grass, 28 oz. The produce per acre . . .	304920	0=	19057	8 0

	oz.	or lbs. per acre.		
80 dr. of grass weigh when dry . . 16 dr. The produce of the space, ditto . . 89.2⅔	60984	0=	3811	8 0
The weight lost by the produce of one acre in drying . .			15246	0 0
64 dr. of grass afford of nutritive matter 2.3 dr. The produce of the space, ditto . . 19.1	13102	0=	818	14 0
The weight of nutritive matter which is lost by leaving the crop till the seed is ripe, exceeding one-third part of its value . . .			372	3 8

The proportional value which the grass, at the time the seed is ripe, bears to that at the time of flowering, is as 11 to 12.

XLV. *Festuca dumetorum.* Flor. Dan. 700.
Pubescent fescue-grass. Nat. of Britain.

At the time of flowering, the produce from a black sandy loam is—

Grass, 16 oz. The produce per acre . . .	174240	0=	10890	0 0
80 dr. of grass weigh when dry . . 40 dr. The produce of the space, ditto . . 128	87120	0=	5445	0 0
The weight lost by the produce of one acre in drying . .			5445	0 0
64 dr. of grass afford of nutritive matter 1 dr. The produce of the space, ditto . . 4	2722	8=	170	2 8

XLVI. *Poa fertilis.* Host. G. A.
Fertile meadow-grass. Nat. of Germany.

At the time of flowering, the produce from a clayey loam is—

Grass, 22 oz. The produce per acre . . .	239580	0=	14973	12 0
80 dr. of grass weigh when dry . . 42 dr. The produce of the space, ditto . . 184⅘	125779	8=	7861	3 8
The weight lost by the produce of one acre in drying . .			7111	8 8
64 dr. of grass afford of nutritive matter 4.2 dr. The produce of the space, ditto . 24.3	16845	7=	1052	13 7

If the nutritive powers and produce of this species be compared with any other of the same family, or such as resemble it in habit and the soil which it affects, a superiority will be found, which ranks this as one of the most valuable grasses; next to the *Poa angustifolia*, it produces the greatest abundance of early foliage, of the best quality, which fully compensates for the comparative lateness of flowering.

XLVII. *Arundo colorata.* Hort. Kew. i. p. 174. Engl. Bot. 402. Phalaris arundinacea.
Striped-leaved reed-grass. Nat. of Britain.

At the time of flowering, the produce from a black sandy loam is—

Grass, 40 oz. The produce per acre . .	435600	0=	27225	0 0

	oz.	or lbs. per acre.		
80 dr. of grass weigh when dry . . 36 dr. The produce of the space, ditto . . 288	196020	0=12251	4	0
64 dr. of grass afford of nutritive matter 4 dr. The produce of the space, ditto . 40	27225	0= 1701	9	0

The strong nutritive powers which this grass possesses recommend it to the notice of occupiers of strong clayey lands which cannot be drained. Its produce is great, and the foliage will not be denominated coarse, if compared with those which afford a produce equal in quantity.

XLVIII. *Trifolium pratense.* W. Bot. iii. p. 137. Broad-leaved cultivated clover. Nat. of Britain.

At the time the seed is ripe, the produce from a rich clayey loam is—

Grass, 72 oz. The produce per acre . .	784080	0=49005	0	0
80 dr. of grass weigh when dry . 20 dr. The produce of the space, ditto . 288	196020	0=12251	0	0
The weight lost by the produce of one acre in drying . .		3675	4	0
64 dr. of grass afford of nutritive matter 2.2 dr. The produce of the space, ditto . 45	30628	2= 1914	4	2

If the weight which is lost by the produce of this species of clover, in drying, be compared with that of many of the natural grasses, its inferior value for the purpose of hay, compared to its value for green food or pasture, will appear; for it is certain that the difficulty of making good hay increases in proportion with the quantity of superfluous moisture which the grass may contain. Its value for green food, or pasture, may further be seen by comparing its nutritive powers with those manifested by other plants generally esteemed best for this purpose.

Trifolium pratense (as above) affords of nutritive matter - - - 2.2 dr.

XLIX. *Trifolium repens* (white clover) from an equal quantity of grass 2.0 dr.

L. Ditto, variety, with brown leaves, ditto 2.2

The grass of the *T. pratense*, therefore, exceeds in value that of the *T. repens* by a proportion as 8 to 10; but it is of equal proportional value with the brown variety.

LI. *Burnet* (Poterium sanguisorba) affords of nutritive matter - - - - 2.2 dr.

LII. *Brunias orientalis* (a newly introduced plant) ditto - - - 2.2

The proportional value of these two last, and of the *T. pratense*, and the brown-leaved variety of *T. repens*, are equal: they exceed the *T. repens* as 8 to 10.

The comparative produce of these four last-mentioned species, per acre, has not been ascertained.

LIII. *Trifolium macrorhizum.* Log-rooted clover. Nat. of Hungary.

At the time the seed is ripe, the produce from a rich clayey loam is—

	oz.	or lbs. per acre.		
Grass, 144 oz. The produce per acre .	1568160	0=98010	0	0
80 dr. of grass weigh when dry . . 34 dr. The produce of the space, ditto . . 979⅓	666468	0=41654	4	0
The weight lost by the produce of one acre in drying . .		56355	12	0
64 dr. of grass afford of nutritive matter 2.3 dr. The produce of the space, ditto . 99	67381	14= 4211	5	14

The root of this species of clover is biennial; it penetrates to a great depth in the ground, and is in consequence little affected by the extremes of wet or dry weather. It requires good shelter, and a deep soil. The produce, when compared to that of others that are allied to it in habit and place of growth, proves greatly superior. The following particulars, some of which refer to results stated in the next two pages, will make this manifest:—

		lbs.
Trifolium pratense, Broad-leaved clover	Produces per acre, Grass	49005
	Ditto, Hay	12251
	Affords, do., of nutritive matter	1914
Medicago sativa, Lucern. From a soil of the like nature	Produces per acre, Grass	70785
	Ditto, Hay	28314
	Affords of nutritive matter	1659
Hedysarum onobrychis, Saintfoin	Produces per acre, Grass	8848
	Ditto, Hay	3536
	Affords of nutritive matter	314

The weight of nutritive matter afforded by the produce of the *T. macrorhizum*, exceeding that of the *T. pratense* in proportion nearly as 7 to 15 . . . lbs. 2297

The proportional value of the grass of *T. pratense*, to that of *T. macrorhizum*, is 10 to 11.

The weight of nutritive matter afforded by the *T. macrorhizum*, exceeding that of the *Medicago sativa* in proportion nearly as 13 to 33 . . . 2552

The proportional value of the grass is as 11 to 6.

The weight of nutritive matter which is afforded by the produce of the *T. macrorhizum*, exceeding that of the *Hedysarum onobrychis* in proportion as 5 to 67 3897

The proportional value of the grass, like that of the *T. pratense*, is as 11 to 10.

The produce of each of the above-mentioned species was taken from a similar soil, and in the same situation; the conclusions must therefore be considered positive with respect to such soils only. It is evident that more than twice the quantity of nutritive matter is afforded by the produce of one acre of the *T. macrorhizum*, than from the produce of an equal space covered by the *T. pratense*. Its short duration in the soil (for if sown early in the autumn, on a rich light soil, it is only an annual plant) renders it fit only for green-food or hay; this in some measure lessens its value when compared with the *T. pratense*. It possesses the essential property of affording abundance of good seed; and if the ground be kept clear of weeds, it sows itself, vegetates, and grows rapidly, without covering-in, or any operation whatever. For four years it has propagated itself in this manner, on the space of ground which it now occupies, and from which this statement of its comparative value is made. The produce of lucern in grass comes nearer to this species in quan-

tity, but is greatly deficient in nutritive matter, as much as 13 to 33. The long continuance of lucern in the soil is therefore the only merit which it possesses above the two last-mentioned species; and when that is the object of the cultivator, it will of necessity have the preference.

The value of the grass of saintfoin is equal to that of the *T. pratense;* and proportionally less than that of the *Trifolium macrorhizum*, as 10 to 11. The quantity of grass is very small, and on soils of the nature above described it is doubtless inferior. However, from the superior value of the grass, on dry hilly situations, or chalky soils, it may in such situations possibly be their superior in every respect.

LIV. *Medicago Sativa.* Wither. B. iii. p. 643. Lucern. Nat. of Brit.

At the time the seed is ripe, the produce from a rich clayey loam is—

	oz.	or lbs. per acre.
Grass, 104 oz. The produce per acre	1132560	0=70785 0 0
80 dr. of grass weigh when dry 32 dr. The produce of the space, ditto 665·2⅔	453024	0=28314 0 0
The weight lost by the produce of one acre in drying	42471	0 0
64 dr. of grass afford of nutritive matter 1.2 dr. The produce of the space, ditto 39	26544	6= 7659 0 6

LV. *Hedysarum onobrychis.* Wither. iii. p. 628. Saintfoin. Nat. of Britain.

At the time the seed is ripe, the produce from a rich clayey loam is—

Grass, 13 oz. The produce per acre	141570	0= 8848 2 0
80 dr. of grass weigh when dry 32 dr. The produce of the space, ditto 83⅓	56628	0= 3539 4 0
The weight lost by the produce of one acre in drying	5308	14 0
64 dr. of grass afford of nutritive matter 2.2 dr. The produce of the space, ditto 8.0½	5530	1= 345 10 1

LVI. *Hordeum pratense.* Engl. Bot. 409. Host. G. A. i. t. 33.
Meadow barley-grass. Nat. of Britain.

At the time of flowering, the produce from a brown loam, with manure, is—

Grass, 12 oz. The produce per acre	130680	0= 8167 8 0
80 dr. of grass weigh when dry 32 dr. The produce of the space, ditto 67.1	52272	0= 3267 0 0
The weight lost by the produce of one acre in drying	4900	8 0
64 dr. of grass afford of nutritive matter 3.3 dr. The produce of the space, ditto 11.1	7657	0= 478 9 0

LVII. *Poa compressa.* Engl. Bot. 365.
Flat-stalked meadow-grass. Nat. of Brit.

At the time of flowering, the produce from a gravelly soil, with manure, is—

Grass, 5 oz. The produce per acre	54450	0= 3403 2 0
80 dr. of grass weigh when dry 34 dr. The produce of the space, ditto 34	23141	4= 1446 5 4
The weight lost by the produce of one acre in drying	1956	12 12
64 dr. of grass afford of nutritive matter 5 dr. The produce of the space, ditto 6.1	4253	14= 265 13 14

The specific characters of this species are much the same as those of the *Poa fertilis*, differing in the compressed figure of the straws, and creeping root only. If the produce was of magnitude, it would be one of the most valuable grasses; for it produces foliage early in the spring, and possesses strong nutritive powers.

LVIII. *Poa aquatica.* Curt. Lond. Engl. Bot. 1315.
Reed meadow-grass. Nat. of Britain.

At the time of flowering, the produce from a strong tenacious clay is—

Grass, 186 oz. The produce per acre	2025540	= 126596 4 0
80 dr. of grass weigh when dry 48 dr. The produce of the space, ditto 1785.2 2/16	1215324	= 75957 12 0
The weight lost by the produce of one acre in drying	50638	8 0
64 dr. of grass afford of nutritive matter 2.2 dr. The produce of the space, ditto 116.1	79122	= 4945 2 10

LIX. *Aira aquatica.* Curt. Lond. Engl. Bot. 1557.
Water hair-grass. Nat. of Britain.

At the time of flowering, the produce from water is—

Grass, 16 oz. The produce per acre	174240	0= 10890 0 0
80 dr. of grass weigh when dry 24 dr. The produce of the space, ditto 76.3 1/16	52272	0= 3267 0 0
The weight lost by the produce of one acre in drying	7623	0 0
64 dr. of grass afford of nutritive matter 2.1 dr. The produce of the space, ditto 9	6122	10= 382 13 10

LX. *Bromus cristatus.* Triticum cristatum, H. G. A. 2. t. 24. Secale prostratum. Jacquin. Nat. of Germany.

At the time of flowering, the produce from a clayey loam is—

Grass, 13 oz. The produce per acre	141570	0= 8848 0 0
80 dr. of grass weigh when dry 32 dr. The produce of the space, ditto 83.1	56628	0= 3539 4 0
The weight lost by the produce of one acre in drying	5308	14 0
64 dr. of grass afford of nutritive matter 2.2 dr. The produce of the space, ditto 8.0 2/16	5530	1= 345 10 0

LXI. *Elymus Sibiricus.* Hort. K. i. p. 176. Cult. 1758, by Mr. P. Millar.

Siberian lyme-grass. Nat. of Siberia.

At the time of flowering, the produce from a sandy loam, with manure, is—

	oz.		or lbs. per acre.		
Grass, 24 oz. The produce per acre	261360	0=	16335	0	0
80 dr. of grass weigh when dry - 28 dr. The produce of the space, ditto - 1341.$\frac{3}{5}$	91476	0=	5717	4	0
The weight lost by the produce of one acre in drying			10617	12	0
64 dr. of grass afford of nutritive matter 2.1 dr. The produce of the space, ditto - 13.2	9188	7=	511	7	0

LXII. *Aira cæspitosa.* Host. G. A. ii. t. 42. Engl. Bot. 1557.

Turfy hair-grass. Nat. of Britain.

At the time the seed is ripe, the produce from a strong tenacious clay is—

Grass, 15 oz. The produce per acre	163350	6=	10209	6	0
80 dr. of grass weigh when dry - 26 dr. The produce of the space, ditto - 135$\frac{1}{5}$	53088	12=	3318	0	12
The weight lost by the produce of one acre in drying			6891	5	4
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto - 7.2	5104	11=	319	0	1

LXIII. *Hordeum murinum.* Curt. Lond. Engl. Bot. 1971.

Wall barley-grass. Way Bennet. Nat. of Britain.

At the time of flowering, the produce from a clayey loam is—

Grass, 18 oz. The produce per acre	196020	0=	12251	4	0
80 dr. of grass weigh when dry - - 28 dr. The produce of the space, ditto - - 100.3$\frac{1}{5}$	68607	0=	4287	15	0
The weight lost by the produce of one acre in drying			7963	5	0
64 dr. of grass afford of nutritive matter 3 dr. The produce of the space, ditto - 3.3$\frac{3}{16}$	2679	15=	167	7	15

LXIV. *Avena flavescens.* Curt. Lond. Engl. Bot. 952.

Yellow oat-grass. Nat. of Britain.

At the time of flowering, the produce from a clayey loam is—

Grass 12 oz. The produce per acre	130680	0=	8167	8	0
80 dr. of grass weigh when dry - 28 dr. The produce of the space, ditto - 67.1	45738	0=	2858	10	0
The weight lost by the produce of one acre in drying			5308	14	0
64 dr. of grass afford of nutritive matter 3.3 dr. The produce of the space, ditto - 11.1	7657	0=	478	9	0

At the time the seed is ripe, the produce is—

	oz.		or lbs. per acre.		
Grass, 18 oz. The produce per acre	196020	0=	12251	4	0
80 dr. of grass weigh when dry - 32 dr. The produce of the space, ditto - 115.0$\frac{4}{5}$	78408	0=	4900	8	0
The weight lost by the produce of one acre in drying			7350	12	0
64 dr. of grass afford of nutritive matter 2.1 dr. The produce of the space, ditto - 10.0$\frac{1}{2}$	6891	5=	430	11	5
The weight of nutritive matter which is lost if the crop be left till the seed be ripe, exceeding one-tenth part of its value			47	13	11

The proportional value which the grass at the time the seed is ripe, bears to that at the time of flowering, is as 9 to 15.

The produce of latter-math is—

Grass, 6 oz. The produce per acre	65340	0=	4083	12	0
64 dr. of grass afford of nutritive matter 1.1 dr.	1276	2=	79	12	2

The proportional value which the grass of the latter-math bears to that at the time of flowering, is as 5 to 15; and to that at the time the seed is ripe, as 5 to 9.

This species is pretty generally cultivated in many parts of this kingdom; and it appears from the above details to be a valuable grass, though inferior to many others.

LXV. *Bromus sterilis.* Engl. Bot. 1030. Host. G. A. i. t. 16.

Barren brome-grass. Nat. of Britain.

At the time of flowering, the produce from a sandy soil is—

Grass, 44 oz. The produce per acre	479160.	0=	29947	8	0
80 dr. of grass weigh when dry - 45 dr. The produce of the space ditto - 396	269527	8=	16845	7	8
The weight lost by the produce of one acre in drying			13102	0	8
64 dr. of grass afford of nutritive matter 5 dr. The produce of the space, ditto - 55	37434	6=	2339	10	0

64 dr. of the flowers afford of nutritive matter 2.2 dr. The nutritive powers of the straws and leaves are, therefore, more than twice as great as those of the flowers. This species, being strictly annual, is of comparatively little value. The above particulars show that it has very considerable nutritive powers, more than its name would imply, if taken at the time of flowering; but if left till the seed be ripe, it is like all other annuals, comparatively of no value.

LXVI. *Holcus mollis.* Curt. Lond. Wither. B. ii. p. 134.

Creeping soft-grass. Nat. of Britain.

At the time of flowering, the produce from a sandy soil is—

Grass, 50 oz. The produce per acre	544500	0=	34031	4	0
80 dr. of grass weigh when dry - 32 dr. The produce of the space, ditto - 320	217800	0=	13612	8	0

		oz.	or lbs. per acre.		
The weight lost by the produce of one acre in drying			20418	12	0
64 dr. of grass afford of nutritive matter 4.2 dr. / The produce of the space, ditto 56.1		38285	2=	2392	13 2

At the time the seed is ripe, the produce is—

Grass, 31 oz. The produce per acre		337590	0=	21099	6 0
80 dr. of grass weigh when dry 32 dr. / The produce of the space, ditto 198.1⅗		135036	0=	8439	12 0
The weight lost by the produce of one acre in drying				12659	10 0
64 dr. of grass afford of nutritive matter 3.2 dr. / The produce of the space, ditto 27.0⅘		18461	15=	1153	13 15
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, being nearly one-half of its value				1238	15 3

64 dr. of the roots afford of nutritive matter 5.2 dr.

The proportional value which the grass at the time the seed is ripe, bears to that at the time of flowering, is as 14 to 18.

The above details prove this grass to have merits which, if compared with those of other species, rank it with some of the best grasses. The small loss of weight which it sustains in dry ing might be expected from the nature of the substance of the grass; and the loss of weight at each period is equal. The grass affords the greatest quantity of nutritive matter when in flower, which makes it rank as one of those best adapted for hay.

LXVII. *Poa fertilis.* Var. B. Host. G. A. The species.
Fertile meadow-grass. Variety 1. Nat. of Germany.

At the time of flowering, the produce from a brown sandy loam is—

Grass, 23 oz. The produce per acre		250470	0=	15654	6 0
80 dr. of grass weigh when dry 34 dr. / The produce of the space, ditto 156⅗		106448	0=	6653	8 0
The weight lost by the produce of one acre in drying				9000	14 0
64 dr. of grass afford of nutritive matter 3 dr. / The produce of the space, ditto 17.1		11740	12=	733	12 12

At the time the seed is ripe, the produce is—

Grass, 22 oz. The produce per acre		239580	0=	14978	12 0
80 dr. of grass weigh when dry 44 dr. / The produce of the space, ditto 193.2		131769	0=	8235	9 0
The weight lost by the produce of one acre in drying				6738	3 0
64 dr. of grass afford of nutritive matter 5 dr. / The produce of the space, ditto 27.2		18717	3=	1169	13 3
The weight of nutritive matter which is lost by taking the crop at the time of flowering, exceeding one-third part of its value, is				436	1 3

The proportional value which the grass at the time of flowering bears to that at the time the seed is ripe, is as 12 to 20.

The produce of latter-math is—

		oz.	or lbs. per acre.		
Grass, 7 oz. The produce per acre		76230	0=	4764	6 0
64 dr. of grass afford of nutritive matter 1.2 dr.		1786	10=	111	10 10

The proportional value which the grass of the latter-math bears to that at the time of flowering, is as 6 to 12; and to that at the time the seed is ripe, as 6 to 20.

LXVIII. *Cynosurus erucæformis.* Beckmannia erucæformis. Host. G. A. iii. t. 6.
Linear-spiked dog's-tail grass. Nat. of Germany.

At the time the seed is ripe, the produce is—

Grass, 18 oz. The produce per acre		196020	0=	12251	4 0
80 dr. of grass weigh when dry 36 dr. / The produce of the space, ditto 129.2⅖		88209	0=	5513	1 0
The weight lost by the produce of one acre in drying				6738	3 0
64 dr. of grass afford of nutritive matter 3.1 dr. / The produce of the space, ditto 14.2¾		9954	2=	622	2 2

LXIX. *Phleum nodosum.* With. B. ii. p. 118.
Bulbous-stalked cat's-tail grass. Nat. of Britain.

At the time of flowering, the produce from a clayey loam is—

Grass, 18 oz. The produce per acre		196020	0=	12251	4 0
80 dr. of grass weigh when dry 38 dr. / The produce of the space, ditto 136⅘		93109	8=	5819	5 8
The weight lost by the produce of one acre in drying				6431	14 0
64 dr. of grass afford of nutritive matter 2.2 dr. / The produce of the space, ditto 11.1		7657	0=	478	9 0

This grass is inferior in many respects to the *Phleum pratense.* It is sparingly found in meadows. From the number of bulbs which grow out of the straws, a greater portion of nutritive matter might have been expected. This seems to prove that these bulbs do not form so valuable a part of the plant as the joints, which are so conspicuous in the *Phleum pratense,* the nutritive powers of which exceed those of the *P. nodosum,* as 8 to 28.

LXX. *Phleum pratense.* Wither. ii. p. 117.
Meadow cat's-tail grass. Nat. of Britain.

At the time of flowering, the produce from a clayey loam is—

Grass, 60 oz. The produce per acre		653400	0=	40837	8 0
80 dr. of grass weigh when dry 34 dr. / The produce of the space, ditto 408		277695	0=	17355	15 0
The weight lost by the produce of one acre in drying				23481	9 0

	oz.	or lbs. per acre.		
65 dr. of grass afford of nutritive matter 2 2 dr. / The produce of the space, ditto - 37.2	25523	7=	1595	3 0
The weight of nutritive matter which is lost by leaving the crop till the seed be ripe, exceeding one-half of its value			2073	11 0

At the time the seed is ripe the produce is—

Grass, 60 oz. The produce per acre - -	653400	0=	40837	8 0
80 dr. of grass weigh when dry - 38 dr. / The produce of the space, ditto - 456	310365	0=	19397	13 0
The weight lost by the produce of one acre in drying - -			21439	11 0
64 dr. of grass afford of nutritive matter 5.3 dr. / The produce of the space, ditto - - 86.1	58703	14=	3668	15 14

The latter-math produce is—

Grass 14 oz. The produce per acre - -	152460	0=	9528	12 0
64 dr. of grass afford of nutritive matter 2 dr.	4764	6=	297	12 6

64 dr. of the straws afford of nutritive matter 7 dr. The nutritive powers of the straws simply, therefore, exceed those of the leaves, in proportion as 28 to 8; and the grass at the time of flowering, to that at the time the seed is ripe, as 10 to 23; and the latter-math, to the grass of the flowering crop, as 8 to 10.

The comparative merits of this grass will appear from the above particulars to be very great; to which may be added the abundance of fine foliage that it produces early in the spring. In this respect it is inferior to the *Poa fertilis* and *Poa angustifolia* only. The value of the straws at the time the seed is ripe exceeds that of the grass at the time of flowering, as 23 to 10; a circumstance which increases its value above many others; for, by this property, its valuable early foliage may be cropped to an advanced period of the season without injury to the crop of hay, which in other grasses which send forth their flowering straws early in the season would cause a loss of nearly one-half of the value of the crop, as is clearly proved by former examples; and this property of the straws makes the plant peculiarly valuable for the purpose of hay.

LXXI. *Phleum pratense.* Var. minor. Wither. B. ii. p. 118. Var. 1.
Meadow cat's-tail grass. Var. Smaller. Nat. of Britain.

At the time of ripening the seed, the produce from a clayey loam is—

Grass, 40 oz. The produce per acre . .	435600	0=	27225	0 0
80 dr. of grass weigh when dry - - - 34 dr. / The produce of the space, ditto - - 272	185130	0=	11570	10 0
The weight lost by the produce of one acre in drying - - - -			15654	6 0
64 dr. of grass afford of nutritive matter 2.3 dr. / The produce of the space, ditto - 272	1817	3=	1169	13 3

The latter-math produce is—

Grass, 14 oz. The produce per acre - - -	152460	0=	9528	12 0
64 dr. of grass afford of nutritive matter 1.2 dr. -	3573	4=	223	5 4

LXXII. *Elymus arenarius.* Engl. Bot. 1672.
Upright sea lyme-grass. Nat. of Brit.

At the time the seed is ripe, the produce from a clayey loam is—

Grass, 64 oz. The produce per acre - - -	696960	0=	43560	0 0
80 dr. of grass weigh when dry - - 45 dr. / The produce of the space, ditto - - 576	392040	0=	24502	8 0
The weight lost by the produce of one acre in drying - - - -			18957	8 0
64 dr. of grass afford of nutritive matter 5 dr. / The produce of the space, ditto - - 80	54450	0=	3403	2 0

LXXIII. *Elymus geniculatus.* Pendulous lyme-grass. Engl. Bot. 1586.
Pendulous sea-lyme-grass. Nat. of England.

At the time of flowering, the produce from a sandy soil is—

Grass, 30 oz. The produce per acre - - -	326700	0=	20418	12 0
80 dr. of grass weigh when dry - - 32 dr. / The produce of the space, ditto - - 192	130680	0=	8167	8 0
The weight lost by the produce of one acre in drying - - - -			12251	4 0
64 dr. of grass afford of nutritive matter 3.1 dr. / The produce of the space, ditto - 24.1½	16590	3=	1036	14 3

LXXIV. *Bromus inermis.* Host. G. A. i. t. 9.
Awnless brome-grass. Nat. of Germany. Introduced by Mr. Hunneman in 1794.

At the time the seed is ripe, the produce from a black sandy soil is—

Grass, 18 oz. The produce per acre - -	196020	0=	12251	4 0
80 dr. of grass weigh when dry - - 35 dr. / The produce of the space, ditto - - 126	85758	12=	5359	14 12
The weight lost by the produce of one acre in drying - - - -			6891	5 4
64 dr. of grass afford of nutritive matter 4.1 dr. / The produce of the space, ditto - - 19.0⅗	13016	15=	813	8 15

The produce of the latter-math is—

Grass 13 oz. The produce per acre - - -	141570	0=	8848	2 0
64 dr. of grass afford of nutritive matter 1.1 dr. -	2765	0=	172	13 0

LXXV. *Agrostis vulgaris.* Wither. Bot. ii. 132. Hud. A. capilaris; Dr. Smith, A. arenaria.
Fine bent-grass. Nat. of Britain.

At the time the seed is ripe, the produce from a sandy soil is—

Grass, 14 oz. The produce per acre - - -	152460	0=	9528	12 0
80 dr. of grass weigh when dry 40 dr. / The produce of the space, ditto - - 112	76230	0=	4764	6 0

	oz.	or lbs. per acre.
The weight lost by the produce of one acre in drying - - - -	4764	6 0
64 dr. of grass afford of nutritive matter $1.2\frac{3}{16}$ / The produce of the space, ditto - - $5.1\frac{1}{16}$	4019 15	= 251 3 15

This is one of the most common of the bents, likewise the earliest; in these respects it is superior to all others of the same family, but inferior to several of them in produce and the quantity of nutritive matter it affords. As the species of this family are generally rejected by the cultivator on account of the lateness of their flowering, and this circumstance, as has already been observed, does not always imply a proportional lateness of foliage, their comparative merits in this respect may be better seen by bringing them into one view, as to the value of their early foliage.

	The apparent difference of time.	Their nutritive powers.
Agrostis vulgaris	Middle of April -	$1.2\frac{3}{4}$
palustris	One week later -	2.3
stolonifera	Two ditto - -	3.2
canina	Ditto, ditto - -	1.3
stricta	Ditto, ditto - -	1.2
nivea	Three weeks, ditto -	2
littoralis	Ditto, ditto -	3
repens	Ditto, ditto -	3
mexicana	Ditto, ditto -	2
fasicularis	Ditto, ditto -	2

LXXVI. *Agrostis palustris.* Wither. Bot. ii. p. 129. Var. 2, alba. Engl. Bot. 1189. A. alba.

Marsh bent-grass.

At the time of flowering, the produce from a bog earth is—

	oz.	or lbs. per acre.
Grass, 15 oz. The produce per acre - -	163350	6 = 10209 6 0
80 dr. of grass weigh when dry - - 36 dr. / The produce of the space, ditto - - 108	73507	8 = 4594 3 8
The weight lost by the produce of one acre in drying - - - -	5615	2 8
64 dr. of grass afford of nutritive matter 2.3 dr. / The produce of the space, ditto - $10.1\frac{1}{4}$	7018 15	= 438 10 15

At the time the seed is ripe, the produce is—

Grass, 20 oz. The produce per acre - -	217800	0 = 13612 8 0
80 dr. of grass weigh when dry - - 32 dr. / The produce of the space, ditto - - 128	87120	0 = 5445 0 0
The weight lost by the produce of one acre in drying - - - -	8167	8 0
64 dr. of grass afford of nutritive matter 2.3 dr. / The produce of the space, ditto - - 13.3	9358	9 = 584 14 9
The weight of nutritive matter which is lost by taking the crop at the time of flowering, being one-fourth part of its value - - - - - - - -		146 3 10

The proportional value of grass in each crop is equal.

LXXVII. *Panicum dactylon.* Engl. Bot. 850. Host. G. A. ii. t. 18.

Creeping Panic grass. Nat. of Britain.

At the time of flowering, the produce from a sandy loam, with manure, is—

	oz.	or lbs. per acre.
Grass, 46 oz. The produce per acre - - -	500940	0 = 31308 12 0
80 dr. of grass weigh when dry - - 36 dr. / The produce of the space, ditto - - $331.0\frac{4}{5}$	225423	0 = 14088 15 0
The weight lost by the produce of one acre in drying - - - -	17219	13 0
64 dr. of grass afford of nutritive matter 2 dr. / The produce of the space, ditto - - 23	15654	6 = 9783 6 0

LXXVIII. *Agrostis stolonifera.* Engl. Bot. 1532. Wither. Bot. ii. 181. (Fiorin, Dr. Richardson.)

Creeping bent. Nat. of Britain.

At the time of flowering, the produce from a bog soil is—

Grass, 26 oz. The produce per acre - - -	283140	0 = 17696 4 0
80 dr. of grass weigh when dry - - 35 dr. / The produce of the space, ditto - - 182	123873	12 = 7742 1 12
The weight lost by the produce of one acre - - - - - - -	9732	15 0
64 dr. of grass afford of nutritive matter 3.2 dr. / The produce of the space, ditto - - 22.3	15484	3 = 967 12 0

At the time the seed is ripe, the produce is—

Grass, 28 oz. The produce per acre - - -	304920	0 = 19057 8 0
80 dr. of grass weigh when dry - - 36 dr. / The produce of the space, ditto - - $201.2\frac{2}{5}$	137214	0 = 8575 14 0
The weight lost by the produce of one acre in drying - - - -	10481	10 0
64 dr. of grass afford of nutritive matter 3.2 dr. / The produce of the space, ditto - 24.2	16675	0 = 1042 3 5
The weight of nutritive matter which is lost by taking the crop at the time of flowering, being nearly one-fourteenth of its value - - - -		74 7 2

LXXIX. *Agrostis stolonifera.* Var. angustifolia. Creeping bent, with narrow leaves. Nat. of Britain.

At the time the seed is ripe, the produce from a bog soil is—

Grass, 26 oz. The produce per acre - -	261360	0 = 16335 0 0
80 dr. of grass weigh when dry - - 36 dr. / The produce of the space, ditto - - $172.3\frac{1}{5}$	117612	0 = 7350 12 0
The weight lost by the produce of one acre in drying - - -	8984	4 0
64 dr. of grass afford of nutritive matter 3 dr. / The produce of the space, ditto - - 18	12251	4 = 765 11 4
The weight of nutritive matter afforded by the produce of one acre of the *Agrostis stolonifera* exceeding that of the variety in proportion, as 6 to 8 -		276 8 1

The above details will assist the farmer in deciding on the comparative value of this grass. From a careful examination it will doubtless ap-

pear to possess merits well worthy of attention, though perhaps not so great as has been supposed, if the natural place of its growth and habits be impartially taken into the account. From the couchant nature of this grass, it is denominated couch-grass by practical men; and from the length of time that it retains the vital power, after being taken out of the soil, is called squitch, quick, full of life, &c.

LXXX. *Agrostis canina.* Engl. Bot. 1856.
Brown-bent. Nat. of Britain.

At the time of flowering, the produce from a brown sandy loam is—

	oz.		or lbs. per acre.		
Grass, 9 oz. The produce per acre - -	98010	0=	6125	10	0
80 dr. of grass weigh when dry - - 34 dr. / The produce of the space, ditto - - 63⅕	43013	0=	2588	5	0
The weight lost by the produce of one acre in drying - - - -			3437	5	0
64 dr. of grass afford of nutritive matter 2.2 dr. / The produce of the space, ditto - - 52.1½	3828	8=	239	4	8

LXXXI. *Agrostis canina.* Var. muticæ.
Awnless brown bent. Nat. of Britain.

At the time the seed is ripe, the produce from a sandy soil is—

Grass, 21 oz. The produce per acre - -	228690	0=	14293	2	0
80 dr. of grass weigh when dry - 24 dr. / The produce of the space, ditto - 100.3⅕	68607	0=	4287	15	0
The weight lost by the produce of one acre in drying - -			10005	3	0
64 dr. of grass afford of nutritive matter 1.3 dr. / The produce of the space, ditto - 9.0¾	6253	3=	390	13	3
The weight of nutritive matter which the produce of one acre of the awnless variety exceeds that of the last mentioned species - -			151	8	11

LXXXII. *Agrostis stricta.* Curt. A. rubra.
Upright bent-grass. Nat. of Britain.

At the time the seed is ripe, the produce from a bog soil is—

Grass, 11 oz. The produce per acre - - -	119790	0=	7486	14	0
80 dr. of grass weigh when dry - 29 dr. / The produce of the space, ditto - 63⅘	43423	14=	2713	15	0
The weight lost by the produce of one acre in drying - - -			4772	15	0
64 dr. of grass afford of nutritive matter 1.2 dr. / The produce of the space, ditto - - 4.0 5/16	2807	9=	175	7	5

LXXXIII. *Agrostis nivea.*
Snowy bent-grass. Nat. of Britain.

At the time the seed is ripe, the produce from a sandy soil is—

Grass, 7 oz. The produce per acre - - -	76230	0=	4764	6	0
80 dr. of grass weigh when dry - - 22 dr. / The produce of the space, ditto - - 30.3⅕	20963	4=	1310	3	0
The weight lost by the produce of one acre in drying - -			2454	3	0
64 dr. of grass afford of nutritive matter 2 dr. / The produce of the space, ditto - - 3½	2382	3=	148	14	3

LXXXIV. *Agrostis fascicularis.* Huds. Var. canina. Curt.
Tufted-leaved bent. Nat. of Britain.

At the time of flowering, the produce from a light sandy soil is—

Grass, 4 oz. The produce per acre - -	43560	0=	2722	8	0
80 dr. of grass weigh when dry - 20 dr. / The produce of the space, ditto - 16	10890	0=	680	10	9
The weight lost by the produce of one acre in drying - -			2041	14	0
64 dr. of grass afford of nutritive matter 2 dr. / The produce of the space, ditto - 2	1361	4=	85	1	4

LXXXV. *Festuca pinnata.* Bromus pinnatus. Engl. Bot. 730.
Spiked fescue. Nat. of Britain.

At the time the seed is ripe, the produce from a light sandy soil, with manure, is—

Grass, 30 oz. The produce per acre - -	326700	0=	20418	12	0
80 dr. of grass weigh when dry - 32 dr. / The produce of the space, ditto - 192	130680	0=	8167	8	0
The weight lost by the produce of one acre in drying - -			12251	4	0
64 dr. of grass afford of nutritive matter 1.1 dr. / The produce of the space, ditto - 9.1¾	6380	13=	398	12	13

LXXXVI. *Panicum viride.* Curt. Lond. Engl. Bot. 875.
Green panic grass. Nat. of Britain.

At the time the seed is ripe, the produce from a light sandy soil is—

Grass, 8 oz. The produce per acre - -	87120	0=	5445	0	0
80 dr. of grass weigh when dry - - 32 dr. / The produce of the space, ditto - 51⅕	34848	0=	2178	0	0
The weight lost by the produce of one acre in drying - - -			3267	0	0
64 dr. of grass afford of nutritive matter 1.2 dr. / The produce of the space, ditto - - 3	241	14=	127	9	14

LXXXVII. *Panicum sanguinale.* Curt. Lond. Engl. Bot. 849.
Blood-colored panic grass. Nat. of Britain.

At the time the seed is ripe, the produce from a sandy soil is—

Grass 10 oz. The produce per acre - -	108900	0=	6806	4	0
64 dr. of grass afford of nutritive matter 1.0 3/16 dr.	1914	4=	119	10	4

This and the preceding species are strictly annual, and from the results of this trial their nutri-

tive powers appear to be very inconsiderable. The seed of this species Mr. Schreber describes (in Beschreibung der Graser) as the manna grass. In Poland, Lithuania, &c., it is collected in great abundance, when, after being thoroughly separated from the husks, it is fit for use. When boiled with milk, or wine, it forms an extremely palatable food, and is most commonly made use of whole, in the manner of sago, to which it is in general preferred.

LXXXVIII. *Agrostis lobata.* Curtis, lobata et arenaria.
Lobed bent-grass.

At the time of flowering, the produce from a sandy soil is—

	oz.	or lbs. per acre.
Grass, 10 oz. The produce per acre	108900	0= 6806 4 0
80 dr. of grass weigh when dry - - 40 dr. The produce of the space, ditto - - 80	54450	0= 3403 2 0
The weight lost by the produce of one acre in drying		3403 2 0
64 dr. of grass afford of nutritive matter 3 dr. The produce of the space, ditto - 7.2	5104	11= 319 0 11

LXXXIX. *Agrostis repens.* Wither. Bot. A. nigra.
Creeping-rooted bent, black bent. Nat. of Britain.

At the time of flowering, the produce from a clayey loam is—

Grass, 9 oz. The produce per acre	98010	0= 6125 10 0
80 dr. of grass weigh when dry - - 35 dr. The produce of the space, ditto - - 63	42879	6= 2679 15 6
The weight lost by the produce of one acre in drying		3445 10 10
64 dr. of grass afford of nutritive matter 3 dr. The produce of the space, ditto - - 6.3	4594	3= 287 2 8

XC. *Agrostis mexicana.* Hort. Kew. i. p. 150.
Mexican bent-grass. Nat. of S. America. Introduced, 1780, by M. G. Alexander.

At the time of flowering, the produce from a black sandy soil is—

Grass, 28 oz. The produce per acre	304920	0=19057 8 0
80 dr. of grass weigh when dry - - 28 dr. The produce of the space, ditto - 156.3⅓	106722	0= 6670 2 0
The weight lost by the produce of one acre in drying		12387 6 0
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto - - 14	9528	12= 595 8 12

XCI. *Stipa pennata.* Engl. Bot. 1356.
Long-awned feather grass. Nat. of Britain.

At the time of flowering, the produce from a heath soil is—

Grass, 14 oz. The produce per acre	152460	0=9528 12 0
80 dr. of grass weigh when dry - - 29 dr. The produce of the space, ditto - - 81⅕	55266	12= 3454 2 12
The weight lost by the produce of one acre in drying		6074 9 4
64 dr. of grass afford of nutritive matter 1.3 dr. The produce of the space, ditto - - 9.2½	6551	0= 409 7 0

XCII. *Triticum repens.* Engl. Bot. 909.
Creeping-rooted wheat-grass. Nat. of Britain.

At the time of flowering, the produce from a light clayey loam is—

Grass, 18 oz. The produce per acre	196020	0=12251 4 0
80 dr. of grass weigh when dry - - 32 dr. The produce of the space, ditto - - 115⅕	78408	0= 4900 8 0
The weight lost by the produce of one acre in drying		7350 12 0
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto - - 9	6125	10= 382 13 10

64 dr. of the roots afford of nutritive matter 5.3 dr. The proportional value of the roots is therefore to that of the grass, as 23 to 8.

XCIII. *Alopecurus agrestis.* Engl. Bot. 848. A. myosuroides.
Slender fox-tail grass. Nat. of Britain. Curt. Lond.

At the time of flowering, the produce from a light sandy loam is—

Grass, 12 oz. The produce per acre	130680	0= 8167 8 0
80 dr. of grass weigh when dry - - 31 dr. The produce of the space, ditto - - 74.1⅗	50638	8= 3164 14 8
64 dr. of grass afford of nutritive matter 1.3 dr. The produce of the space, ditto - - 5.1	3573	4= 223 5 4

XCIV. *Bromus asper.* Engl. Bot. 1172. Curt. Lond. Bromus hirsutus. Huds. Bromus ramosus. B. sylvaticus, volger. B. altissimus.
Hairy-stalked brome-grass. Nat. of Britain.

At the time of flowering, the produce from a light sandy soil is—

Grass, 20 oz. The produce per acre	217800	0= 13612 8 0
80 dr. of grass weigh when dry - - 24 dr. The produce of the space, ditto - 96	65340	0= 4083 12 0
The weight lost by the produce of one acre in drying		9528 12 0
64 dr. of grass afford of nutritive matter 2 dr. The produce of the space, ditto - - 10	6806	4= 425 6 4

XCV. *Phalaris canariensis.* Engl. Bot. 1310.
Common canary-grass. Nat. of Britain.

At the time of flowering, the produce from a clayey loam is—

	oz.	or lbs. per acre.		
Grass, 80 oz. The produce per acre - -	871200	0=54450	0	0
80 dr. of grass weigh when dry - - 26 dr. The produce of the space, ditto - - 416	283177	8=17697	9	8
The produce in weight lost by drying		36752	6	6
64 dr. of grass afford of nutritive matter 1.2 dr. The produce of the space, ditto - 30	20418	12= 1876	2	12

XCVI. *Melica cærulea.* Curt. Lond. Engl. Bot. 750.

Purple melic grass. Nat. of Britain.

At the time of flowering, the produce from a light sandy soil is—

Grass, 11 oz. The produce per acre - -	119790	0= 7486	14	0
85 dr. of grass weigh when dry - 30 dr. The produce of the space, ditto - 66	44921	4= 2807	9	4
The weight lost by the produce of one acre in drying - - -		4679	4	2
64 dr. of grass afford of nutritive matter 1.2 dr. The produce of the space, ditto - 2.0¾	2756	8= 172	4	8

XCVII. *Dactylis cynosuroides.* Linn. fil. fasci. 1. p. 17.

American cock's-foot grass. Nat. of N. America.

At the time of flowering, the produce from a clayey loam is—

Grass, 102 oz. The produce per acre - -	111780	0= 69423	1	0
80 dr. of grass weigh when dry - 48 dr. The produce of the space, ditto - 979⅕	666468	0= 41654	4	0
The weight lost by the produce of one acre in drying - -		27769	8	0
64 dr. of grass afford of nutritive matter 1.3 dr. The produce of the space, ditto - 44.2¾	30372	0= 1898	4	0

Of the time in which different Grasses produce Flowers and Seeds.

To decide positively the exact period or season when a grass always comes into flower, and perfects its seed, will be found impracticable; for a variety of circumstances interfere. Each species seems to possess a peculiar life, in which various periods may be distinctly marked, according to the varieties of its age, of the seasons, soils, exposures, and mode of culture.

The following table, which shows the time of flowering, and the time of ripening the seed of those grasses growing at Woburn which are mentioned in the Experiments, must therefore only be considered as serving for a test of comparison, for the different grasses growing under the same circumstances.

Names.	Time of flowering.	Time of ripening the seed.
Anthoxanthum odoratum	April 29	June 21
Holcus odoratus	April 29	June 25
Cynosurus cæruleus	April 30	June 20
Alopecurus pratensis	May 20	June 24
Alopecurus alpinus	May 20	June 24
Poa alpina	May 30	June 30
Poa pratensis	May 30	July 14
Poa cærulea	May 30	July 14
Avena pubescens	June 13	July 8
Festuca hordiformis	June 13	July 10
Poa trivialis	June 13	July 10
Festuca glauca	June 13	July 10
Festuca glabra	June 16	July 10
Festuca rubra	June 20	July 10
Festuca ovina	June 24	July 10
Briza media	June 24	July 10
Dactylis glomerata	June 24	July 14
Bromus tectorum	June 24	July 16
Festuca cambrica	June 28	July 16
Bromus diandrus	June 28	July 16
Poa angustifolia	June 28	July 16
Avena elatior	June 28	July 16
Poa elatior	June 28	July 16
Festuca duriuscula	July 1	July 20
Milium effusum	July 1	July 20
Festuca pratensis	July 1	July 20
Lolium perenne	July 1	July 20
Cynosurus cristatus	July 6	July 28
Avena pratensis	July 6	July 20
Bromus multiflorus	July 6	July 28
Festuca loliacea	July 1	July 28
Poa cristata	July 4	July 28
Festuca myurus	July 6	July 28
Aira flexuosa	July 6	July 28
Hordeum bulbosum	July 10	July 28
Festuca calamaria	July 10	July 28
Bromus littoreus	July 12	Aug. 6
Festuca elatior	July 12	Aug. 6
Nardus stricta	July 12	Aug. 6
Triticum (species of)	July 12	Aug. 10
Festuca fluitans	July 14	Aug. 12
Festuca dumetorum	July 14	July 20
Holcus lanatus	July 14	July 26
Poa fertilis	July 14	July 28
Arundo colorata	July 16	July 28
Poa (species of)	July 16	July 30
Cynosurus erucæformis	July 16	July 30
Phleum nodosum	July 16	July 30
Phleum pratense	July 16	July 30
Elymus arenarius	July 16	July 30
Elymus geniculatus	July 18	July 30
Trifolium pratense	July 18	July 30
Trifolium machrorhizum	July 18	July 30
Sanguisorba canadensis	July 18	July 30
Bunias orientalis	July 18	July 30
Medicago sativa	July 18	Aug. 6
Hedysarum onobrychis	July 18	Aug. 8
Hordeum pratense	July 20	Aug. 8
Poa compressa	July 20	Aug. 8
Poa aquatica	July 20	Aug. 8
Bromus cristatus	July 24	Aug. 10
Elymus sibiricus	July 24	Aug. 10
Aira cæspitosa	July 24	Aug. 10
Avena flavescens	July 24	Aug. 15
Bromus sterilis	July 24	Aug. 20
Holcus mollis	July 24	Aug. 20
Bromus inermis	July 24	Aug. 20
Agrostis vulgaris	July 24	Aug. 20
Agrostis palustris	July 28	Aug. 28

Names.	Time of flowering.	Time of ripening the seed.
Panicum dactylon	July 28	Aug. 28
Agrostis stolonifera	July 28	Aug. 28
Agrostis stolonifera (var.)	July 28	Aug. 28
Agrostis canina	July 28	Aug. 28
Agrostis stricta	July 28	Aug. 30
Festuca pennata	July 28	Aug. 30
Panicum viride	Aug. 2	Aug. 15
Panicum sanguinale	Aug. 6	Aug. 20
Agrostis lobata	Aug. 6	Aug. 20
Agrostis repens	Aug. 8	Aug. 25
Agrostis fascicularis	Aug. 10	Aug. 30
Agrostis nivea	Aug. 10	Aug. 30
Triticum repens	Aug. 10	Aug. 30
Alopecurus agrestis	Aug. 10	Sept. 8
Bromus asper	Aug. 10	Sept. 10
Agrostis mexicana	Aug. 15	Sept. 25
Stipa pennata	Aug. 15	Sept. 25
Melica cærulea	Aug. 20	Sept. 30
Phalaris canariensis	Aug. 50	Sept. 30
Dactylis cynosuroides*	Aug. 30	Oct. 20

Of the different Soils referred to in the Appendix.

In books on agriculture and gardening much uncertainty and confusion arise from the want of regular definitions of the various soils, to distinguish them specifically by the names generally used: thus the term "bog-earth" is almost constantly confounded with peat-moss, and heath-soil; also the terms "light loam," "heavy soil," &c. are given without distinguishing whether that be "light" from sand, or this "heavy" from clay. In minute experiments, it is doubtless of consequence to be as explicit as possible in those particulars. The following short descriptions of such soils as are mentioned in the details of the experiment are here given for the above purpose:—

1st. By "loam" is meant any of the earths combined with decayed animal or vegetable matter.

2d. "Clayey-loam," when the greatest proportion is clay.

3d. "Sandy-loam," when the greatest proportion is sand.

4th. "Brown-loam," when the greatest proportion consists of decayed vegetable matter.

5th "Rich black loam," when sand, clay, animal and vegetable matters are combined in unequal proportions, the clay greatly divided, being in the least proportion, and the sand and vegetable matter in the greatest.

The terms "light sandy soil," "light brown loam," &c. are varieties of the above, as expressed.

Observations on the Chemical Composition of the Nutritive Matter afforded by the Grasses in their different states.—By Sir H. Davy.

I have made experiments on most of the soluble products supposed to contain the nutritive matter of the grasses, obtained by Mr. Sinclair; and I have analyzed a few of them. Minute details on this subject would be little interesting to the agriculturist, and would occupy a considerable space; I shall therefore content myself with mentioning some particular facts, and some general conclusions, which may tend to elucidate the inquiry respecting the fitness of the different grasses for permanent pasture, or for alternation as green crops with grain.

The only substances which I have detected in the soluble matters procured from the grasses are mucilage, sugar, bitter extract, a substance analogous to albumen, and different saline matters. Some of the products from the after-math crops gave feeble indications of the tanning principle.

The order in which these are nutritive has been mentioned in the first lecture: the albumen, sugar, and mucilage, probably when cattle feed on grass or hay, are for the most part retained in the body of the animal; and the bitter principle, extract, saline matter, and tannin, when any exist, probably for the most part are voided in the excrement with the woody fibre. The extractive matter obtained by boiling the fresh dung of cows is extremely similar in chemical characters to that existing in the soluble products from the grasses. And some extract, obtained by Mr. Sinclair from the dung of sheep and of deer, which had been feeding upon the Lolium perenne, Dactylis glomerata, and Trifolium repens, had qualities so analogous to those of the extractive matters obtained from the leaves of the grasses, that they might be mistaken for each other. The extract of the dung, after being kept for some weeks, had still the odor of hay. Suspecting that some undigested grass might have remained in the dung, which might have furnished mucilage and sugar as well as bitter extract, I examined the soluble matter very carefully for these substances. It did not yield an atom of sugar, and scarcely a sensible quantity of mucilage.

Mr. Sinclair, in comparing the quantities of soluble matter afforded by the mixed leaves of the Lolium perenne, Dactylis glomerata, and Trifolium repens, and that obtained from the dung of cattle fed upon them, found their relative proportions as 50 to 13.

It appears probable from these facts that the bitter extract, though soluble in a large quantity of water, is very little nutritive; but probably it serves the purpose of preventing to a certain extent, the fermentation of the other vegetable matters, or in modifying or assisting the function of digestion, and may thus be of considerable use in forming a constituent part of the food of cattle. A small quantity of bitter extract and saline matter is probably all that is needed; and beyond this quantity the soluble matters must be more nutritive in proportion as they contain more albumen, sugar, and mucilage, and less nutritive in proportion as they contain other substances.

In comparing the composition of the soluble products afforded by different crops from the same grass, I found, in all trials I made, the largest quantity of truly nutritive matter in the crop cut when the seed was ripe, and least bitter extract and saline matter; most extract and saline matter in the autumnal crop; and most saccharine matter, in proportion to the other ingredients, in the crop cut at the time of flowering. I shall give one instance—

100 parts of the soluble matter obtained from the Dactylis glomerata, cut in flower, afforded

* In the experiments made on the quantity of nutritive matter in the grasses cut at the time the seed was ripe, the seeds were always separated; and the calculations for nutritive matter, as is evident from the details, made for grass and not hay.

of sugar - - - 18 parts.
of mucilage - - - 67
of colored extract, and saline matters with some matter rendered insoluble by evaporation 15

100 parts of the soluble matter from the seed crop afforded—

of sugar - - - - 9 parts,
of mucilage - - - 85
of extract, insoluble and saline matter - - - 6

100 parts of the soluble matter from the after-math crop give—

of sugar - - - 11 parts.
of mucilage - - 59
of extract, insoluble and saline matters - - - 30

The greater proportion of leaves in the spring, and particularly in the late autumnal crop, accounts for the difference in the quantity of extract; and the inferiority of the comparative quantity of sugar in the summer crop probably depends upon the agency of light, which tends always in plants to convert saccharine matter into mucilage or starch.

Amongst the soluble matters afforded by the different grasses, that of the Elymus arenarius was remarkable for the quantity of saccharine matter it contained, amounting to more than one-third of its weight. The soluble matters from the different species of Festuca, in general, afforded more bitter extractive matter than those from the different species of Poa. The nutritive matter from the seed crop of the Poa compressa was almost pure mucilage. The soluble matter of the seed crop of Phleum pratense, or meadow cat's-tail, afforded more sugar than any of the Poa or Festuca species.

The soluble parts of the seed crop of the Holcus mollis and Holcus lanatus contained no bitter extract, and consisted entirely of mucilage and sugar. Those of the Holcus odoratus afforded bitter extract and a peculiar substance having an acrid taste more soluble in alcohol than in water. All the soluble extracts of those grasses that are most liked by cattle have either a saline or sub-acid taste; that of the Holcus lanatus is similar in taste to gum arabic. Probably the Holcus lanatus, which is so common a grass in meadows, might be made palatable to cattle by being sprinkled over with salt.

I have found no differences in the nutritive produce of the crops of the different grasses cut at the same season, which would render it possible to establish a scale of their nutritive powers; but probably the soluble matters of the after-math crop are always from one-sixth to one-third less nutritive than those from the flower or seed crop. In the after-math the extractive and saline matters are certainly usually in excess; but the after-math hay mixed with summer hay, particularly that in which the fox-tail and soft grasses are abundant, would produce an excellent food.

Of the clovers, the soluble matter from the Dutch clover contains most mucilage, and most matter analogous to albumen: all the clovers contain more bitter extract and saline matter than the common proper grasses. When pure clover is to be mixed as fodder, it should be with summer hay, rather than after-math hay.

From the Genesee Farmer.

REMARKS ON THE CULTURE OF PEAS.

Crops of secondary importance are of course deserving of less attention than those which are primary; such as, in consequence of a limited market, do not readily command cash, are not so valuable to the farmer as those at all times in extensive demand. Thus, for instance, the culture of buckwheat and rye are not worthy of so much attention as that of wheat. But when a crop of secondary importance *in itself*, becomes a very useful auxiliary in the cultivation of the most important, it immediately assumes a rank of the first consequence. It is this which renders the cultivation of peas highly deserving the attention of farmers.

It has been long since satisfactorily determined that attemps to make money rapidly from land by close cropping, is the worst economy; and that on the contrary a proper system of rotation, calculated to effect a constant improvement in the soil, is, in consequence of the full and regular crops thus obtained, the best policy even for the time being. Thus an abundant crop of peas followed by one of wheat, would be more advantageous than two successive and inferior crops of wheat, independently of the effect on the land.

The peculiar excellence of peas as a preparation for wheat, is becoming well known. Their additional value as food for fattening domestic animals, especially hogs, renders the knowledge of their proper culture of much importance, and any suggestions therefore upon this subject it is presumed may not be wholly useless.

With regard to the proper soil for peas, it is commonly believed that a poor, or but moderately fertile one, is best; and that the great growth of stalk produced by very rich land, is adverse to the copious production of seed. This is doubtless generally the case, when the larger and taller varieties are sown; in these there is already a strong tendency to the growth of leaf and stalk, which is increased by a fertile soil. But this may doubtless be in a great degree if not entirely remedied, by the substitution for the taller kind, of the early and dwarf varieties, such as Bishop's dwarf prolific and the early Washington. Indeed it is not improbable that much larger crops than have been hitherto obtained, may be raised by dwarf peas thickly sown on fertile ground. Analogous proof is furnished by the fact that much larger crops of Indian corn have been raised in the northern states from the small-stalked varieties, than in the fertile land of the south and west where this plant grows of gigantic size.

An additional advantage from the use of dwarf kinds is early maturity, which is always a very desirable quality in all farm crops, if not at the expense of quantity.

What further experiments are needed and further discoveries are yet to be made in the cultivation of peas on fertile and even on highly manured soils by the use of *lime*, will be evident from the following extract from Dickson's Farmers' Companion:

"It is observed, that the common pea, whether white or gray, cannot be reared to perfection in any field which has not been either naturally or artificially impregnated with some calcareous mat-

ter. But it is remarkable, that a soil that could scarcely have brought one pea to perfection, although richly manured with dung, from their running too much to haum, and after blossoming dying away without becoming ripe, if it has had lime applied upon it, is capable, when properly prepared in other respects, of producing plentiful crops of peas ever after."

The best *time* for sowing peas is as early in the spring as practicable. It is not an uncommon practice among gardeners who cultivate peas for the table, to sow them late in autumn, and the first warm weather in the spring brings them up. The chief objection to this practice is the danger of their being destroyed by mice during winter; but this danger would be small in a clean ploughed field, and an experiment in fall sowing may be well worthy of trial, especially as it is an object to do as much of the work of the farm in autumn as practicable, in order to avoid the hurry of spring. The present is the time for such an experiment.

The *pea-bug* has always been found a serious difficulty in the culture of this crop; and as inquiries have been recently made in this paper for a description, the following is given. The insect, (*Bruchus pisi*) is of an ovate form and brownish color, particularly the elytra (or wing-sheaths) which are uniformly besprinkled with specks and lines of a light color, as well as the upper part of the thorax near the joint. The mouth is armed with a pair of serrated forceps, the under part and legs are of a very dark dusky color, and the whole insect covered with fine hair. When the pods of the pea have arrived at the state of maturity sufficient to show the small peas within them, the female deposits her eggs in the evening or on a cloudy day. These soon hatch, and the young larva eats directly into the young pea, and remains feeding on its contents until it changes into a chrysalis, which takes place before the ensuing spring. The perfect insect emerges during the warm weather, generally about the time of sowing peas. They do not generally leave their habitations until after the peas are planted, (unless purposely exposed to the hot sunbeams,) when they creep out and remain until new crops invite them; after they have deposited their eggs they perish. When the peas are green and scarcely full grown, the presence of the worm is scarcely discernible, and does not affect the taste; but when they are quite ripe, there is nothing but a shell enveloping a fat chrysalis. A most remarkable fact is that they never injure the plumula or sprout, for almost every pea occupied by the insect, grows and thrives vigorously notwithstanding nearly the whole of the internal part appears to be consumed. This remarkable instinct is necessary for their existence; for if the seed were destroyed, it would end in the extermination of their race.

Several methods have been proposed for destroying this insect or eluding its depredations. Soaking them for a minute in boiling water, which does not destroy their vitality, has been repeatedly and confidently recommended as an effectual mode for their destruction. But a correspondent in the second number, current volume, of this paper says, "I poured boiling water upon the peas and let them stand till the water cooled. I then poured off the water and commenced sowing my peas, when to my astonishment the bugs were crawling about as lively as ever." He adds that the vitality of the seed was greatly injured, as not one-half of them came up. A better remedy appears to be in always sowing clean seed. But where, it is asked, is this to be obtained? Clean seed may be procured from Canada; or it may be had by sowing a portion of the field very late, or with old peas, for this particular purpose. It appears that this insect disappears from the seed before the middle of the sixth month (June) and consequently sowing later than this time, or not until the following spring, for the purpose of obtaining seed, would be effectual. Of these two methods, however, sowing seed 2 years old is on the whole undoubtedly the best. By this time, the insect has lived out its period, and no danger from it is to be apprehended.

Peas fed to hogs immediately after harvesting are not hurt for that purpose by the bug.

A very convenient way of raising and feeding peas to hogs is to plant successive crops in different fields, and to allow them to be eaten on the ground. At the time the peas are beginning to harden, they will eat the leaves and stalks as well as the seed. This method is particularly applicable to the fattening of large herds upon land which is cheap and where labor is expensive.

As it is desirable to procure the best varieties of the pea for seed, so it is requisite that care be taken to prevent their deterioration. They seem to be peculiarly liable to change—to improvement by proper care, as well as degeneracy by neglect. It has been observed in the culture of the early Washington, that seed from the same origin differs greatly, merely from the management it receives. Genuine seed of this variety may be obtained, which will ripen a week or two later than other seed, also genuine. The quality of early maturity may be greatly increased or lessened, by always selecting the portion first ripe for sowing, or by picking the earliest for the table, and using the remainder for seed. The following statement in the third volume of the Genesee Farmer, by L. Couch, is well deserving of attention:—

"There is no seed that I am acquainted with that will degenerate more rapidly than peas. The process that I have pursued for *two years* with my seed peas, is simply sifting them in a sieve that will let through the small peas and the small seeds of every description, and leave the largest and the best of the peas to sow. By this means my peas have improved *at least twenty-five per cent. in quality.* I think it answers all the purpose of scalding to clean them of the bugs. By sifting them the bug or nit is shaken out of the peas and left with the rubbish, which is given to hogs."

With regard to other points in the culture of this crop, it may be briefly observed—that plaster, as on clover, operates to the most decided advantage; that a clover sod turned over late in the fall, is an excellent preparation for sowing the following spring; that as deep planting is less liable to prevent vegetation than in most seed, when sown upon a light or dry soil, they should always be buried by a shallow furrow of the plough; that when fed upon the ground to hogs, two or three quarts of oats to the acre intermixed, will afford an excellent support for them during their growth; and that by far the best and most expeditious method of harvesting them is by means of a common horse rake.

J. J. T.

From the Southern Agriculturist.

ON THE IMPROVEMENT OF SOILS IN SOUTH CAROLINA BY MARL.

Mr. Editor,—I take great pleasure in handing for publication, a communication submitted to the South Carolina Agricultural Society, by Dr. Joseph Johnson, on the subject of marl as a manure. It is one fraught with valuable consequences to the whole state, and particularly the lower sections. All lands in the vicinity of a metropolis become more valuable from proximity to a market, and whatever can restore its fertility, demands great consideration. The community therefore are indebted to individuals who offer the means of effecting such a purpose, and when suggestions emanate from so philosophic and practical a mind as Dr. Johnson's, they demand attention and patient experiment. Many sections of country in the vicinity of Charleston, and particularly along the rivers, contain large beds of marl, and the suggestions thrown out may easily be tested. The fertile soil may be sought (as familiary entitled) to the far west, yet even there its properties are not more enduring that at home, and when we consider the privations of possession, of separation from kindred, early association broken, and loss of polished society, which must be all forgone in seeking a due return for labor, it surely becomes us to secure advantages nature presents at home. Let us listen to those then who lure her treasures from her, and avail ourselves of the blessings she tenders. Let us ascertain and estimate the advantages we enjoy. We will then revel under the shade of our own vine and our own fig tree, and our hearts will rejoice with the endearing recollections of home, around the cherished hearths of our ancestors.

The concurrence of Dr. Johnson in publishing his remarks, was politely granted to the corresponding secretary.

R. W. Roper.

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Communication of Dr. Jos. Johnson, *to the Agricultural Society of South-Carolina, on the Improvement of Soils by Marl and Lime, &c.*

Charleston, 20th August, 1838.

Gentlemen,—Most of you have seen the papers occasionally published in the Southern Agriculturist and other periodicals, on the uses of marl and lime as manures for sandy sour, and exhausted lands. Ruffin's Essay on Calcareous Manures, has no doubt been read, by most of you; but you may not be as well informed, that these valuable manures are found in almost every part of our middle and low country; and on the banks of the Savannah, Edisto, Ashley, Cooper, Santee and Pedee rivers, and on many of the intermediate inferior water-courses.

Mr. Wm. Scarborough, who lived 15 or 20 years ago, on the Lower-Three-Runs in Barnwell District, told me that he had accidentally discovered a bed of marl in digging a ditch, and applied it to his very poor high land, in the proportion recommended by agriculturists. Even in the first year, the benefit was very evident; in the second it was greately increased, and in the third year, the produce of his marled land was threefold greater than it ever had been previous to the addition of marl.

Mr. Morton A. Waring tried it one year only, on a piece of land which he then owned on Ashly river. The produce was increased even in that first year about 50 per cent., but as he then sold the place he did not know whether it had been cultivated in the succeeding years or not.

Mr. James B. Richardson, the present representative from Sumter district in our state legislature, told me that he had procured some fossil shells from Santee river, made lime of them, and applied the lime to some of his old fields, which had once been first rate land. The consequence was, that they became more productive than they ever had been, even when first cleared. Some of you may know of other instances of success, I never heard of a failure where the cultivation was continued.

But practical knowledge is much wanted on this subject; and even if the proportion of marl to each acre recommended by the most approved writers on this subject, be applied to our lands, some difference may be discovered in our soils, or in our marls, or in some other respect.

It is first of all desirable to know whether the marl within our reach, is composed of lime, clay and sand, in proportions which would encourage us to dig and cart it to our old fields. This question will be readily answered by any gentleman acquainted with chemistry. I have analyzed several specimens, and will cheerfully continue to afford every information in my power. All marls effervesce if vinegar be poured on them, and this test is within the reach of every inhabitant, however distant he may be from those who can give more certain and correct information.

It is next desirable to know at what time, and in what quantities, marl should be laid on the fields. These questions I request of your society to have ascertained by the experiments of practical men. I suggest that the time which can be best spared for such works, is the best time. When the crop is laid by in the summer, the marl may be dug out and left to dry in heaps. In the winter it may be carted into the fields, and scattered in the trenches to moulder until the spring, when the plough can do all that is farther necessary. Mr. Ruffin thinks that the best way is to keep one man constantly employed with a horse and cart, all through the year, and that 60 acres may be thus effectually manured in one year, requiring no other or additional manure for 7 or 8 years.*

The quantity required varies from 200 to 300 bushels per acre, according to the quality of the marl and the nature of the land. The cost of manuring would therefore be from $2 to $5 per acre, which I suppose to be cheaper than clearing land, where the wood cannot be sent down to a market. If the returns for this expenditure, equal those reported in Virginia and New-Jersey, the crop will be increased three-fold, say from 10 to 30 bushels per acre. The profit would therefore be increased not only $20 per acre for one year, but as no other manuring is required for 7 or 8 years, it would be at least $120 per acre, returned for $5 expended. If 20 acres be cultivated in corn by one boy and horse, he will make for his owner $500 or $600

* The last words of this passage do not correctly convey the opinions of the work intended to have been quoted. Marl is there considered as a *permanent* manure.—Ed. Farm. Reg.

per annum, corn being supposed to sell at $1 per bushel. In affording this profit, he would only work at the crop three or four months, all the rest of the year, he might be employed in marling other lands.

So many laborers have been taken off from the cultivation of provisions in the United States, to become the consumers of provisions, while laboring in the construction of Rail-Roads and other public works, that provisions cannot be otherwise than dear, for many years to come. The planter who most successfully cultivates provisions, will therefore be best rewarded, while cotton is at the present moderate rates.

But, gentlemen, there are other considerations of great importance to most of us. Most of us have children, relatives and friends, who have left the state and gone westwardly, to seek for new lands. Many more, distinguished for talents and enterprise and public spirit, may be expected to follow, unless something can be done at home to afford them profitable occupation. The rank of South-Carolina among her sister states, will be diminished in proportion to her diminished population and productions. I trust that something may yet be done, not only to arrest this emigration, and render agriculture more profitable, but to render the number of persons engaged in agriculture, much more numerous than has ever been known, at least in the middle and lower portions of the state. Are not the most of you, gentlemen, owners of uncultivated lands in this portion of the state, for which there has hitherto been no demand, nor any prospect of their being wanted, for cultivation? If by the successful use of marl and shells, the old fields in their vicinity can be increased in their productions, from 10 to 30 bushels per acre, would not the value of such lands be increased in proportion, and would not you, the proprietors, find your property doubled in value by the discovery? Would not all other lands in the vicinity of the marl and shells, although never settled, be improved in proportion with the old fields, and will not the proprietors reap the benefit, whatever that may be?

If you can make it appear to a farmer that he can live with his family in a pine land settlement, enjoying health and every other comfort in life, while he can lay up $400 or $500 per annum, from the work of every one of his family who can plough a neighboring field; are not such men likely to become settlers on these vacant lands, and increase their value? Are they not more likely to settle on these lands, when they ascertain that they may cultivate both a winter and a summer crop in the same year? If these advantages be made known in Europe, are not the skilful experienced peasantry in the north of Italy, in Switzerland, Germany, Holland, Poland, and other parts of Europe, likely to collect in this part of our state, and form a population of hardy yeomen, who would quiet all apprehensions of a domestic nature? With such prospects and probabilities, is it not worth our while, to set on foot a series of experiments, for the purpose of ascertaining how far the marl and shells found in South-Carolina, may be made to increase the agricuitural productions of the country?

Lime and marl are the most durable of all manures; but the latter, in particular, requires about three years to perfect its influence over the land. It will therefore be necessary to continue the experiment at least three years in succession; it may also be expedient to manure and cultivate a new piece of adjacent ground each year, by way of testing what had preceded.

With much deference, I propose that your society offer a premium for the best series of experiments with marl found in South-Carolina, on a stated quantity of sandy land, and continued three years—the quantity of marl applied to each acre, and the productions of each acre being distinctly reported to the society, with any other circumstance deemed important by you.

The same premium for the same experiments on clay land.

The same premium for the same experiments with unburnt, pulverized or mouldering shells, or loose limestone, both on sandy and clay lands.

The same premium for the same experiments with lime burnt from shells, or from loose limestone, both on sandy and clay lands.

I beg leave to submit these suggestions for the consideration of the Agricultural Society, subject, of course, to any amendments or alterations that they may think expedient. Their greater knowledge and experience must dictate.

I am, very respectfully,
Your most obedient servant,
JOS. JOHNSON.

To the President and Members of the Agricultural Society.

From the Southern Agriculturist.

GRASSES, ETC. FOR SHEEP.

Mr. Editor,—As your valuable work is open to all subjects connected with the husbandry of our country, and more particularly this southern portion of it, I beg leave to occupy a small space. The growing of wool does not much interest us at present, but the time is coming when it may be necessary for us to make every edge cut. Whether so or not, there are always among us those who are found of good and sound mutton, and many who are deterred from raising sheep by fear of the rot, and other disorders. My experience may remove a portion of that fear. I take no more than ordinary care of mine in winter, but I observe in the pine barren where they pasture, a species of creeping pepper grass of which they are very fond. It comes up early in February, and dies in the summer. The stimulating warmth of this food, preserves them in health, and keeps them free of the rot, and other diseases so fatal to sheep, in cold rainy seasons. Those who have the pepper grass, and desire to raise sheep, should encourage the growth of it. There are other plants and grasses, which being pungent, will answer eqally well, and of which sheep are fond. Among them are mint, penny-royal, and parsley. Satisfied with my spontaneous growth of pepper grass, I have not cultivated either of the last mentioned aromatics, but I think their having a good effect on sheep cannot be doubted. I would advise cultivation of the pepper grass however, in preference, but only because it is more proper and natural to recommend more highly what I *know*, than what I only believe, no matter how confidently. It is certain however that sheep take

freely all the plants I have named. If this communication instructs but one individual, I shall be happy in having done some little, towards advancing the husbandry of my native state.

Edgefield. A FARMER.

For the Farmers' Register.

ROUGH FIELD NOTES.

No. II.

Philadelphia and Reading Rail-Road.

There is no work in Pennsylvania more interesting, or, as far as finished, better executed than this. For several months the navigation of the Schuylkill improvement is closed by ice, and great difficulty is experienced in transporting coal from the extensive coal region of Pottsville, and that section of the state, to market. To remedy this evil was the Philadelphia and Reading railway projected. When completed, it will not stop, as its name would indicate, at Reading, but will extend to Pottsville, a distance of 93 miles, and will there connect with the rail-road from that place to Sunbury, and also with the numerous little roads radiating from Pottsville to every coal mine in the neighborhood. When this road shall have been finished to the coal region, the amount of transportation it will do will be immense.

From Philadelphia, to a point opposite Norristown, 18 miles, the road is yet unfinished. The traveller, for the present, leaves Philadelphia on the Norristown rail-road, and, at its termination, crosses over to the Reading road, which is completed from that point to Reading, a distance of forty miles. Between Reading and Pottsville, ground has just been broken; but, from the energy and success with which this great work has heretofore been prosecuted, there is no doubt but that it will steadily progress till completed.

This road all the way pursues the valley of the Schuylkill, being located on the southern side for thirty miles from Philadelphia, and then crossing to the northern. With a few exceptions, it conforms to all the windings of the river, and its location partakes of the same general nature as that of the Baltimore and Ohio rail-road along the valley of the Patapsco, except that the bends of the Schuylkill being generally less sudden and the valley wider, more gentle curves have been obtained throughout. There is no curve between Philadelphia and Reading with a radius less than 950 feet, and, with one or two exceptions, the curves have radii as much as 2000 feet, or more. The hills sometimes encroach on the river, confining the roadway, and causing either deep side-cutting, oftentimes through rock, or expensive walling on the river side. Near Phœnixville, the Schuylkill makes a circuitous bend of three miles, and returns to within half a mile of the place from which it set out, forming a bold promontory one and a half miles long, and only half a mile across the neck. To save the three miles of distance, and, at the same time, to avoid much bold curvature, it was determined to tunnel under this neck of land, which is a spur from the main ridge. This tunnel was commenced in 1835, and has been successfully carried through. It is the greatest work of the kind in America, and no man ought to visit Philadelphia without going to see this triumph of art. It is 1932 feet long, 19 feet wide, and 17 feet high, with an elliptical arch. It is cut through a dark-colored graywacke slate, from which it derives its name of "Black Rock tunnel." It was excavated from both ends as well as from six vertical shafts. These shafts are eight feet in diameter, and were sunk in pairs to enable the miners the better to keep the true line of direction. The deepest shaft is 140 feet deep. A true and accurate line has been obtained through the tunnel for the rail-road, showing the accuracy with which it was excavated, and the greatest care and attention on the part of the resident engineer. The cost of the shafts, per cubic yard, was $20, and of the tunnel itself, $5. The whole cost of this tunnel was about $170,000. On the first division of this road, there is also another tunnel, about 900 feet long, not yet completed: and it is more than probable that there will be another near Port Clinton.

Immediately at the far end of Black Rock tunnel, and on a line with it, is a handsome bridge of hewn sandstone, across the Schuylkill, by means of which the rail-road crosses to the northern side of the river. This viaduct has four arches, each with a span of 72 feet, and a rise of 16½ feet. Each arch is the arc of a circle, and contains 53 ring-stones, which measure 30 inches in depth. The road-way is 16½ feet in the clear between the parapets, which are of sandstone, 2 feet wide, and project two feet above the road-way. The piers are not what are termed abutment piers, being only eight feet thick. The wings of the abutments have a radius of 18½ feet, and terminate by steps descending to the surface of the ground. The execution of this costly bridge is good, but the architectural effect is not pleasing. The very slight projection of the pilasters which go up from the piers, and the nicety with which the material has been cut, give a delicacy of appearance altogether unbecoming a structure of this nature. The arches, too, springing at an elevation of only six feet above ordinary water, would have looked better had they been elliptical, instead of circular, particularly if the faces of the piers had also been slightly curved. The Thomas viaduct across the Patapsco on the Washington branch rail-road, produces a much finer effect, and is not surpassed by any similar work in our country. The Thomas viaduct is built of unhewn granite of the best quality. It is 660 feet long, 66 feet above the surface of the water, and consists of 8 circular arches of 60 feet span each. Each abutment is 60 feet long, and terminated by strong buttresses on each side. Heavy pilasters also go up from every pier. The road-way is 22 feet wide, and is confined on either side by a heavy iron railing, 3½ feet high on the top of the parapet, which is 2½ feet wide. The whole work presents the appearance of great strength and stability. The cost of this bridge was $120,000. It is worthy of note, that this immense bridge is built on a curve, with a radius, to judge by the eye, of 2800 feet.

In the construction of the bridge across the Schuylkill, the necessary precautions were not taken to guard against ice, which frequently comes down that river in great quantities. The piers below high-water-mark should have been built on the upper side circular, and with a slope of at least 45°, like the piers of the Alexandria aqueduct. Instead of which, however, the piers

are built perfectly perpendicular. Since the bridge was finished, they have placed just above each pier what they call ice-breakers, (of wood,) but which forcibly remind one of chicken-coops of the present day, and which I have no doubt equalled in expense, the additional cost of the piers, had they been constructed in the proper manner in the beginning.

At the east end of Black Rock tunnel, is a long rock cut, 30 feet deep. The effect of passing rapidly in the train through this cut, the walls of which stand almost vertical, then through the tunnel, which, notwithstanding its 6 shafts, is as dark within as midnight, and dashing across the bridge to the opposite side of the river, with the sudden transition from darkness to light, all in a moment, can hardly be conceived.

As is generally the case with all roads located in the valleys of rivers, on this a great number of bridges of various sizes are necessary for crossing the many tributaries of the Schuylkill. The principal stone structure has been already described. With that exception, for all spans exceeding forty feet, the lattice bridge is used. It is worthy of note, that all the bridges of this kind, notwithstanding the short time the road has been in operation, have settled between the piers. This is owing, I think, to the fact, that they are built for a double track, and that only one has been put down and is in use. The consequence is, that every time a train passes, at least three-fourths of the whole weight is thrown on one side of the bridge, or one set of lattice. This evil may be remedied by a third set of lattice between the two tracks, thus making, as it were, a separate and independent bridge for each track. This additional lattice may be put in, at not much additional cost; and that it is necessary when two tracks are required, is sufficiently proven by the lattice bridges, not only on this road, but throughout the state. This settling has taken place to so great an extent on the Danville and Pottsville railroad, that they are now putting wooden supports between their regular piers.

The Reading railroad was graded throughout for two tracks, but only one has been as yet laid. The superstructure consists of wooden sills, (principally of oak,) 7 × 8 inches, bedded 3 feet 3 inches apart, on beds of broken stone 14 inches deep. Trenches are first dug at the proper distances apart and well rammed. The broken stone is then put in, in three different layers, each layer also being well rammed. On the sills is fastened the T rail, weighing 45 lbs. to the running yard. The rails are 19 feet long, and only rest on cast-iron chains at their extremities. To the intermediate sills they are merely fastened by spikes with *catch* heads. The superstructure was not laid till the banks had had a winter to settle, and is now in admirable adjustment.

There is no grade between Philadelphia and Reading over 18 feet to the mile. This is a most striking feature in this road. An engine without difficulty, will carry 200 tons down to Philadelphia. The fuel used is *coke*, obtained from the gas works. It is found to answer very well. On the Baltimore and Ohio road, anthracite coal is used. Two tons are found necessary to go from Baltimore to Harper's Ferry. An experiment or two had been tried with bituminous coal, and 1 ton 14 cwt. were found to do the same work.

The Philadelphia and Reading railroad passes through a highly interesting country. The scenery of the Schuylkill is not so picturesque as that of the Potomac, but the neat farms and farmhouses, and frequent villages, furnish employment for the eye of the traveller. Just below Reading, the river breaks through the first ridge of hills, under the name of "Never-Sink Mountain."

The cost of this railroad and all its fixtures will be $45,000 per mile.

Danville and Pottsville Railroad.

This road extends from Pottsville, at the head of the Schuylkill improvement, 40 miles to Sunbury, on the Susquehannah. Its object was to transport coal from the anthracite coal region, through which it passes in either direction, to the Schuylkill, or to the Susquehannah. The construction of this road was premature, and the consequence is, that the 12 miles next to Pottsville are not in use, that the next 8 miles have never been finished, and that only 20 miles of it from Shamokin to Sunbury are now used. It is supposed, however, that by the time the Reading railroad is completed to Pottsville, that the completion of this work will be loudly called for.

This road necessarily crosses the dividing ridge between the Schuylkill and Susquehannah, and the inclined planes by which it rises and falls from the summit of the Broad Mountain constitute the most remarkable and interesting feature in this work. Between Pottsville and Girardsville, a distance of only 12 miles, there are not less than six inclined planes, 4 ascending and two descending.

Plane	No.	1	rises	176	feet	in	600	feet
"	"	2	"	200	"	"	850	"
"	"	3	"	130	"	"	600	"
"	"	4	"	130	"	"	800	"
"	"	5	falls	345	"	"	1600	"
"	"	6	"	150	"	"	900	"

In passing over these planes on horseback it is with difficulty that the horse can be led up and down them. All these planes except No. 5 have the same angle of inclination throughout. No. 5 is gradually curved, beginning very precipitously at top, and by degrees becoming more and more gentle towards the bottom. They all have curves approaching within a short distance of their foot, which is decidedly objectionable. The planes have double tracks, and the same sills extend under both. Friction rollers are placed every 25 feet. At the head of plane No. 5, which has a most imposing appearance, is a stationary engine. From Pottsville the road follows the western side of a rugged and precipitous ravine for eight miles. There is much heavy rock cutting and stone walling. Plane No. 4 brings you to the top of Broad Mountain, a bleak and inhospitable region. The eye in vain looks around for any trace of cultivation. For two miles the road keeps on this mountain and descends by plane No. 5 into the valley of the Mahanoy. Between Girardville and Shamokin, the link yet incomplete, one or two inclined planes will be required.

Shamokin is a small and new village, situated at the head of a creek of the same name, which empties into the Susquehannah just below Sunbury. Its origin was the coal trade, and all its inhabitants are colliers and miners. From this

place to Sunbury 20 miles, the rail-road winds down the valley of the Shamokin with generally easy curves through a country, the last half of which is highly cultivated. Grading on this portion is remarkably light, for a road in the midst of mountains. As the road approaches Sunbury it crosses the Shamokin three times by handsome lattice bridges, which, however, have settled very much. I have rarely passed through a region so wild and dreary as that between Pottsville and Shamokin. I was particularly struck with the beauty and grandeur of the hemlock tree, which abounds along the road. When young it contrasts well with, and when old seems well suited to, the rugged cliffs it overshadows.

Just at the head of inclined plane No. 1, is a small tunnel 800 feet long, 10 feet wide and 11 feet high, with a circular arch. It was excavated entirely from the two ends. The material excavated was earth with a small quantity of coal. The sides are walled with stone, and the top arched with brick. The whole cost was $26,000.

This road has been graded for two tracks, but only one has been laid. The superstructure consists of heavy sills bedded every five feet on broken stone, into which is keyed a wooden rail 9×5 inches. The iron plate measures 2 by $\frac{5}{8}$ inch.

From Pottsville to Girardville, 12 miles, cost $400,000. From Shamokin to Sunbury, 19 miles, cost $180,000.

PROCEEDINGS OF THE FREDERICKSBURG AGRICULTURAL SOCIETY.

[Published by request of the Society.]

Tuesday, Nov. 8, 1838.

At 12, M., the society was called to order—James M. Garnett in the chair, and Robert B. Semple, Secretary.

This was a called meeting, for the purpose of reviewing the report of the revising committee on the constitution and by-laws. Report was made through the chairman, Wm. P. Taylor, asking (for reasons therein stated) further time for the committee to discharge its duties, which report was accepted, and the society adjourned.

Annual Meeting—Nov. 9.

The society was called to order by the late secretary, when, on motion, the rule requiring the election of officers by ballot, was suspended, and the society proceeded to the election of their officers for the ensuing year.

On motion of James Richards, James M. Garnett was unanimously re-elected president. George Hamilton having declined a re-election, Francis W. Taliaferro was elected 1st vice president, and Wm. P. Taylor, 2d vice president.

Robert B. Semple (the late secretary) asked to be excused from the further duties of secretary and treasurer, when, at his consent, he was on motion, appointed secretary and treasurer, *pro tem.*

The society then proceeded to vote upon the admission of new members, and the selection of committees, preparatory to the show and fair, and at 12, M., adjourned to witness the exhibition.

Afternoon session.

James M. Garnett in the chair, when the several committees reported.

The committee on stallions, jacks and mules, report—that they examined two stallions, one owned by Mr. Taylor, and the other by Mr. Alcocke. Both horses were in bad condition, but they award the premium to Mr. Alcocke's horse, Corsair, as they consider him the best looking horse of the two.

They also report—that they examined a jack, the property of Mr. Thomas Rowe, of Caroline, to whom they awarded a premium of $10.

They also report—they examined a very fine mule colt of Mr. John C. Browne, two years old, for which they award a premium of $5.

John H. Lee, *Chairman.*

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The committee on mares, colts, fillies and riding horses, have performed the duties assigned them, and beg leave to submit the following report: They award the premium for the best colt to Mr. George Morton's Truffle, two years old last spring. They award a premium for the best brood mare to Mr. Robert Wallace's mare, by———, which had a fine colt at her foot, by Priam. They award to Thomas Chandler a premium for the finest riding horse, though this was not a bloodless victory—it being hard to decide between his horse and a fine sorrel owned by Mr. P. B. Winston, of Louisa—all of which is respectfully submitted.

James Richards, *Chairman.*

—

The committee on beef, sheep and mutton, beg leave to report—that they award the premium on mutton to John B. Gray, of Stafford, and for the best grass-fatted beef, being the only one exhibited, (although a very fine one) to Zephaniah Turner, of Rappahannock county. For the best fatted work ox, to Lewis Shumate, of Fauquier county.

George Rowe.

—

The committee on bulls and milch cows, award the premium for the best bull, (half Devonshire,) to Mr. Hay Taliaferro, of King George. Mr. Green exhibited a fine milch cow, but having no pedigree, the committee did not award a premium.

R. T. Willis, *Chairman.*

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The committee of agricultural implements, report—that the implements exhibited were a cultivator, an ox-yoke, a hand-drill, and a cutting-box. The three first, by Mr. James M. Garnett, and the last, an instrument made at the Fredericksburg foundry. These implements were not offered for premiums, and were not tested by actual trial, and therefore none is recommended; but they think proper to say that they appear to be well adapted for the purposes intended. The cultivator is stated to be a good instrument for opening a furrow, for planting, as well as for the culture of corn, the ox-yoke is reported to be the one always used in Spain; and the hand-drill seems to be well calculated for sowing almost any kind of seed or grain upon land nicely prepared and pulverized. They recommend the trial of these instruments, and also of the cutting-box. The model of a coulter was also exhibited by Mr. Taliaferro, which seems to deserve a trial; but, in this case, as well

as the others, the committee had no opportunity of testing its value.

WM. P. TAYLOR, *Chairman.*

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The committee on flour, report—that they have examined the flour exhibited to them, and award the premium to R. T. Willis, of Orange.

HUGH SCOTT, *Chairman.*

—

Essays on agriculture were read by Dr. Wm. Browne, Wm. P. Taylor, and Robert B. Semple: when the society adjourned, to meet to-morrow at 10, A. M.

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Saturday morning, Nov. 10.

At 10, A. M. the president took the chair. On motion of Wm. P. Taylor, JOHN S. CALDWELL was unanimously elected secretary and treasurer of this society. The following resolution was adopted: Whereas large amounts still remain due upon the books of this society—

Resolved, That the treasurer be directed to draw off the accounts of delinquent subscribers, and forward them to the deputy sheriffs of the counties in which they respectively reside for collection, allowing such commission as he may deem proper, not exceeding 20 per cent.

After the adoption of other resolutions of a private character, the society adjourned to the town hall to witness the exhibition of domestic manufactures, and to hear the president's annual address.

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Afternoon session.

The society met at 3 P. M., the president in the chair, when the report of the committee appointed to examine domestic manufactures was read.

The committee reported that they had discharged the duties assigned them. They regret that the exhibition has been more indifferent than they have ever before seen it. There were fewer articles exhibited, though those that were shown, were of very superior quality. Among those deserving a premium, were the following:

For the best yarn counterpane, L. V. Stevens,	$3
For the best cotton ditto, Mrs. Wm. Rothrock,	3
For the best yarn stockings, Miss Tally,	1
A discretionary premium was awarded to Mrs. Hunter, for sewing silk and a pair of silk stockings, manufactured by herself, of	5
A discretionary premium to Miss A. E. Eliason, for silk stockings,	2
For rug, to Mrs. Wm. Pollock,	3
Mrs. Stevens, for Scotch plaid,	3

The committee examined a specimen of brooms, from the factory of Hunt & Browne, and think them superior to any thing of the kind they have ever seen, and justly entitled to a premium.

The domestics exhibited by the woollens factory of Fredericksburg are recommended as a useful and superior article for servants' clothing.

A carpet was exhibited by Mrs. John Hart, of Fauquier, manufactured of cotton. It was very superior of its kind; but as it was not exhibited for a premium, the committee therefore declined to award one.

The committee further report—that they have examined three suits of clothes; all of which were of superior quality, and displayed great skill in their manufacture. Whilst the suit worn by Mr. Eliason commanded the admiration of the committee, yet, they being dyed and dressed at the fulling mill, placed them in the esteem of the committee out of the rules of the society. The committee, therefore, award the premium to Joseph Sanford.

WM. C. J. ROTHROCK, *Chairman.*

—

The committee on butter, award the premium to Miss Nelly Lee, of Orange.

WM. JACKSON, *Chairman.*

—

A communication was read from Turner H. Ramsey, tendering an annuity of $15 towards the payment of premiums, additional to his annual fee as member of this society. The offer of Mr. Ramsey, was accepted, and the thanks of the society tendered him.

On motion of George Hamilton,

Resolved, That the secretary cause to be procured, a book, in which each individual now a member, or who hereafter may become one, shall register his own name, the date of his becoming a member, and the county in which he resides.

On motion of Wm. P. Taylor,

Resolved, That the annual subscription of each member of this society, on and after the next fall meeting, be $3.

On motion of James M. Garnett,

Resolved, That the Agricultural Essays of Messrs. Browne, Taylor, and Semple, read to this society yesterday, be forwarded to the Farmers' Register, with the request of the society that they be published in that journal.

Resolved, That the proceedings of this society, with the president's address, be published in the Herald and Arena, of Fredericksburg, and the Farmers' Register.

The thanks of the society were, on motion, tendered to the president and secretary—and the society adjourned.

JAMES M. GARNETT, *Pres't.*

R. B. SEMPLE,

Sec'ry. & Treas'r. pro tem.

From a Foreign Journal.

THE MOON.

In the last number of the Monthly Chronicle, we find some statements drawn from astronomical observations, which must be quite new to those who have hitherto supposed this planet to be inhabited by animal beings. The most powerful telescope ever yet constructed does not enable us to see distinctly an object whose visual magnitude is so small as one second, corresponding to a mile on the surface of the moon. It therefore follows that an object, say a town on the moon, measuring a mile across in each direction, would be too small to be discerned by any aid which telescopes have yet supplied. "If the moon be examined," says the writer, "for any length of time with the aid of the most ordinary telescopes, the observer cannot fail to be struck with the unalterable character of the outlines of light and shade upon the surface. These are distinct and well defined, that they may be delineated with great exactness;

and a map exhibiting their appearance at any one time will continue at all times to exhibit that appearance with the same fidelity and precision."

The first inference which he draws from this circumstance is, that the same side of the moon is always turned toward us, and as she turns round on her own axis, in about twenty-seven days and eight hours, the Selenites, or inhabitants of the moon, as denominated from the Greek word 'moon,' must have 328 hours daylight, followed by 328 hours night. The next is, that there are no clouds suspended around her; and a third inference, drawn from other data, is, that there are no indications whatever of seas and water in the moon; and if there is any atmosphere at all, it must be a thousand times less dense than that of the earth. It would require a perfect air pump to produce such a degree of rarefaction under a receiver, and such an atmosphere would, as far as regards all the phenomena of animal and vegetable life, be a vacuum. The following description gives a frightful picture of this silvery orb of night:

"The character of the entire surface of the moon, so far as telescopic power has made it known to us, is just what might have been expected in a world deprived of air and water, and of the tribe of beings to whose life these are necessary. This most inhospitable planet exhibits a wide waste of surface, diversified by nothing but its lofty mountains and cavernous valleys. Chains of mountains and insulated hills are spread over every part of the surface, and lift their menacing and precipitous sides frequently to the height of five perpendicular miles. In many places huge masses of earth spring directly from the plain and carry their peaked summits to the altitude of twenty thousand feet. Nor is the extent of the base of these stupendous eminences less astounding that their heights. The diameters of the bases of several detached hills of this kind, which measure five miles in height, vary from twenty-four to forty-six miles.

"But the circumstance which deprives the moon's surface of every trace of analogy with that of the earth, is the enormous circular cavities which are found in almost every part of it. Some of these caverns are four miles in depth and forty miles in diameter. Their edge is generally defended by a high natural wall. Frequently a conical mountain rises to a considerable height from the bottom of this dark circular hole. The top of this cone is rendered visible when the rays of the sun fall directly into the cavern. This internal conicle mountain has sometimes a circular cavity in its apex like the crater of a volcano.

"The provision which gives to the several planets the grateful returns of the seasons is denied to the moon, and accordingly not a trace can be discovered on her surface of the slightest variation which can be ascribed to change of season.

"If, then, the moon be the habitation of living things, they must be constituted with functions very different from all those which characterize the animal and vegetable kingdoms of the earth. In the absence of atmosphere, the Selenites cannot of course be respiratory animals. Sound, which depends on air for its production and conveyance, there can be none. Speech and hearing would therefore be useless faculties.

"No azure firmament offers its mild tint to the eye of the Selenite. The blue of our sky is the proper color of our atmosphere. In the absence of an atmosphere, the firmament of the moon is one eternal and unvaried black, through which the glowing orb of the sun holds its solitary way, vainly endeavoring to diffuse brightness beyond the edge of his own disc. On the arid and ungrateful waste beneath, his genial rays fall in vain —no atmosphere is present to collect, retain, and diffuse their warmth; and if they fail to sustain animal and vegetable life on the summits of our Alps and Andes, merely because of the rarefied state of the atmosphere at those heights, how much more ineffectual must they be in the absence of any atmosphere whatever.

"Seeng, then, that while we find on all the planets the same provisions to fit them for the dwelling places of creatures like ourselves, and those provisions supplied in the same manner, and to the same extent; and, on the contrary, finding all of those arrangements, without one exception, denied to the moon, we must, in the absence of any direct evidence on this question, come to the conclusion that our satellite is a barren uninhabited waste, playing doubtless some necessary part in the creation, but not the higher one assigned to the earth and planets; that it is, in fine, a desert rock, resting its head in the wide ocean of space, unappropriated to and unfitted for the resting place of any living thing.

For the Farmers' Register.

LEGISLATIVE AID TO AGRICULTURE.

No. I.

Two years have now nearly passed since the advocates for legislative aid being given to agricultural improvement have ceased their previous and earnest efforts for that great object. It was not that the object sought had lost any value in their estimation; or that they did not still think that its attainment was imperiously required for the resuscitation and continued prosperity of the great and general interests of Virginia. But their arguments and petitions had met with no favor from the legislature; and, indeed, scarcely any response, or appearance of hearty concurrence, from the great body of the agriculturists of the country. Under such discouraging circumstances, the most ardent and zealous advocates for governmental aid to agriculture, had no choice but to cease their efforts.

But circumstances of recent occurrence have served to rekindle hope, and to urge to renewed efforts. The commercial convention, which lately held its session in Norfolk, included this subject among the necessary elements of the commercial prosperity of the commonwealth; and *unanimously* approved the report and resolution of the committee on this subject, (which was published in the last No. of the Farmers' Register, p. 570,) and directed committees to present and sustain those views before the then approaching sessions of the legislatures of Virginia and North Carolina. The highly respectable body which directed there proceedings, though called together, and acting mainly, to aid the resuscitation of commerce, was nevertheless composed principally of delegates from the country, who be-

longed exclusively to the agricultural interest. And the delegates from the towns, even if not directly or exclusively members of the agricultural interest, were sufficiently identified with it to render their unanimous decision on this question a strong indication of the opinion of the intelligent community.

Under these favorable auspices, then, this all-important subject will again be brought before the legislature of Virginia; and all private individuals who have heretofore labored for the object, and all who heartily wish its promotion, are called upon to lend their countenance and aid to the recommendation of the convention. For the purpose of aiding in this work, it is the design of the writer to present his views at some length, on the proper subjects for legislative action, in aid of agricultural improvement. In these views, there may, perhaps, be nothing which has not already been stated in the earlier volumes of this work. But without claiming the merit of originality, for the present article, he hopes to be useful if merely confining his labor to digesting, and presenting at one view, the opinions and arguments which are scattered so widely, that no reader, perhaps, remembers, or will take the trouble to refer to them elsewhere.

Before entering upon the consideration of any particular means of aid to agricultural improvement, it is proper to premise that all which are sought, all which are considered legitimate and proper, to be afforded by government, will come under a single head—that of INSTRUCTION, or the collecting and communicating knowledge on agriculture. All means which will aid instruction are good, however they may differ in their degrees of value; and all which will not aid instruction, will be either useless or injurious.

First, let us consider the *right* of the legislature of Virginia, to aid agricultural instruction, and the *expediency* of the exercise.

It is not the legal or constitutional right or power of the legislature, that any one will question. On that head, there is no doubt. The denial of right will only be made on the ground of its being an unsuitable, improper, and unnecessary exercise of legislation. It is on this more extended ground that the question of right will be considered.

Adam Smith, the great head of the free-trade school of political economists, the highest, and deservedly the most venerated authority for restraining (on the score of policy,) all useless legislation, limits the proper action of government to three subjects only. These are 1st. the maintaining of justice between the individuals of the nation governed, and between the nation and foreign powers; 2ndly, the construction or facilitating of great works of acknowledged value, but which are too extensive or costly, for private individuals to execute, either singly, or by agreement between many; 3rdly, the providing for necessary education of the people, in such cases as there are either no sufficient means, or no sufficient demand on the part of the people to secure the supply. It will be admitted that these limitations are abundantly close, to cut off all improper subjects of legislation; though neither these, nor any general limitations, can prevent the improper treatment of legitimate and proper subjects. In the propriety of these close restrictions we fully concur, and claim nothing for agriculture which cannot be clearly deduced from, and be found authorized by these strict rules.

Few, if any, legislators, or private individuals, will deny that it is a right and duty of government to give proper and judicious aid to the general, or literary education of the people, in such cases as the object cannot be attained without the interference of government. Where private and general demand and supply are so established, that such interference or aid is not wanted, then, as in all other cases, the free-trade doctrine correctly and fully applies, and any interference of government would not only be useless, but absolutely hurtful to the cause of education. Thus, the advantages of ordinary schools for teaching the English and even the Latin and Greek languages, are sufficiently appreciated in this country to insure a supply of schools and of teachers; and the government is not only, therefore, not required to furnish such schools, and to pay their teachers, but would certainly do harm to education by every such attempt. But for the highest branches of scientific instruction for those who have by their own efforts gained the necessary previous knowledge, there is not sufficient appreciation, or demand, to ensure a supply of instruction, or of persons competent to instruct; and neither do the most ignorant (in this or any country,) enough prize the elements of the lowest instruction to be willing to pay the smallest pittance for having their children taught. Therefore our government properly and wisely (in design at least, if not in the mode of execution,) interferes in both these cases, and aids, or attempts to aid, both the highest and the lowest branches of education and learning. The necessity of education to all classes is justly considered in regard to the general weal, and not as conferring a boon or benefit on each individual aided. It is highly important to the public interest and public morals, that no citizen should be entirely ignorant of letters; and the state endeavors (though but to little purpose,) by an enormous annual expenditure, to prevent as much as possible that great national evil. It is also highly important that there should be the means afforded within the borders of Virginia, for acquiring the higher branches of scientific education—without any benefit of which a community would soon sink into brutish ignorance—and which, without such means at home, would be gained but by very few, and those, at great expense, and by going abroad. To prevent this great evil, this incalculable waste of money and of intellectual value, the state wisely offers to all those who will prepare themselves at a great previous expense of their own, the means of making themselves still more useful and valuable as members of the commonwealth. These are the true principles and proper grounds for the aid of education by the government. The education conferred may operate very beneficially and profitably to the individual so instructed; but it is not with that view, that it is, or ought to be given, but to render the individual of greater value to his country.

These views are as correctly applied to agriculture as to literary and scientific education; but in a far stronger manner, both as to the existing deficiency of means for gaining knowledge, the great necessity for such means, and the certainty that every gain of profit and income made in consequence of such aid, will also be a gain and pro-

fit to the commonwealth. Before proceeding to the consideration of the proper and best means of furnishing agricultural instruction and knowledge, we beg leave to offer an illustration of the particular position just mentioned. The subject taken for illustration, is chosen, not by any means because it is one of the most important to agriculture, and the commonwealth's interests, but, because it is one which now excites much curiosity, and is one on which there is as yet among us but little knowledge, and no practical experience.

Thousands of the cultivators of Virginia have been recently and violently excited by the speculating mania which has raised the price of mulberry twigs to more than their weight in silver, and design next year to commence the cultivation of the mulberry tree, as largely as circumstances permit, with a view to profit from the expected and extensive culture of silk in this country. Many of these persons are directed by sound views, and design to begin and prosecute a regular, and, as we fully believe, when understood, a profitable business. Many others, it is feared, are impelled merely by a wild and groundless spirit of speculation, in sales of plants. But whatever may be the motives, and whether the wise or the unwise may preponderate, and whatever may be the amount of ultimate profit from the new business of silk culture, *this is certain*, that many thousands of dollars, perhaps hundreds of thousands, will be risked, and wasted, in untried experiments and processes, of which all engaged are entirely ignorant; and it will follow, of course, even though the final results may be profitable to individuals, and highly valuable to the state, still, that a large proportion of all the first enormous outlay of expense, will be sacrificed and lost, because of the inexperience and ignorance of the adventurers. Now, if the state had paid the expense of the first experiment, and had spared no pains and cost to have the trial fairly and fully made, by putting to work the best knowledge and skill in the business, with the best means to operate with, then this expenditure would have served to prevent a hundred fold greater by individuals, and have turned to profit all that will now run to loss. If a mulberry nursery and cocoonry had been established at the public expense, upon the best known plan, and making trial of every supposed improvement, then the problem of the amount of products and of profits would have been already placed beyond question. Such an establishment would also have furnished the best possible school of practical instruction in the business. Every individual who was inclined to commence it, would visit it, and see, not the mere first trials of novices, but all the processes, and the general procedure, of the best and oldest establishments of Europe, as well as trials of every newly proposed improvement. The income of the cocoonry, perhaps, would have paid the greater part of the expense—possibly the whole; but even if the excess of expenditure over income had been $10,000, it would still have operated as a great pecuniary gain to the whole commonwealth, as well as to the numerous individual adventurers. And though this subject, taken for illustration, is a novel and peculiarly strong case of general ignorance, great risks, and consequently great losses, which the state might have prevented at little cost, and to great ultimate profit, yet the like application might be made to various separate and important branches of agricultural industry, as well as to general instruction and diffusion of knowledge on the whole subject.

If it may be permitted to pursue this illustration still farther, it may be affirmed, that if such a silk business and school had been established in Virginia three years ago, among the other lights derived, the peculiar value of the morus multicaulis, or Chinese mulberry, would have been fully ascertained, and its culture generally diffused throughout the state; and consequently the great enhancement of its market price, and the mad speculations founded thereon, either would never have existed, or, if so enhanced, the sales would have brought millions of dollars to the state, for products which cost almost nothing, instead of draining a vast amount from this state to cultivators abroad.

So far, as to the need for agricultural instruction in general, and its value to all who will profit by its being provided. But even if all this be fully admitted, there will then still be opposed the objection of demagogues and popularity-seekers, "that it is unjust to tax the whole population, for the benefit of a part." Though this miserable substitute for argument is brought to oppose every new proposition for beneficial improvement, it never raises its head in the same cause after being once successfully resisted. In truth, there is scarcely a legislative act of any kind, or tax or requisition, which may not as much be said to be a charge to the many for the use or benefit, or demand, of a few, as would be pecuniary grants for the improvement of agriculture in an agricultural community. The complaint is as absurd and as groundless, as if an individual complained of the injustice of his being taxed to support criminal justice, because he was neither a judge to be honored and paid, nor a felon to be hung. But of all such charges of injustice, that against agricultural aids would have the least color. The agricultural interest in Virginia is so extended as almost to be identified with the community in general—and it is certain, that the former cannot possibly be benefited, except to the benefit of the whole commonwealth. The few, who have no direct or immediate interest in agriculture, are indirectly and remotely, but yet considerably interested; and any burden imposed on them in common with all other citizens, for improving agricultural products, would in a far greater degree improve their interest in agriculture, indirect or remote as it may be.

It still might be contended, (at least by court-yard and muster-ground orators, and office-seekers,) that some agriculturists would derive all the benefits, while others would merely share in bearing the cost of the system. This could scarcely happen upon a proper system of instruction, except to those who would blindly and obstinately continue to reject all light and knowledge; and for such cases it would be waste of all effort to attempt to furnish either aid or remedy.

Next, let us consider the peculiar deficiency and want of agricultural education or instruction.

Agriculture, as a science, has been less investigated by competent inquirers, and is less understood, than any others in general use, and deemed important. As an art, it stands still lower; as the necessary processes, even when judiciously planned and directed, are never *all* executed properly on the farm of the most skilful cultivator; and in

most cases, *none* are executed well, and generally all very imperfectly. What would have been the condition of the now admirable and profitable cotton factories of Virginia, if few of their processes were planned, and none executed correctly—if none of the machinery was of the best kind, or in good order, and none of the laborers had skill in their departments? Add to this supposition, that the proprietors, constructors, superintendents and operatives had never seen any better works, and the supposed case is then precisely parallel to agricultural operations in general, and especially to those of Virginia. Every one knows that in the manufacturing business, it is essential to profitable results, that every material element, of general plan, of construction, and of all the daily operations, should be of the best kind known; and no persons would be so foolish and regardless of their interest, as to attempt the business without first buying, at any price, all the benefit of the experience and acquired knowledge of others on the subject, and endeavoring to employ agents and operatives who should be as skilful as those of any other factories. And without such precaution and measures of security, every one would predict that the business would soon come to ruin. Yet the course which all would condemn in this case, as absurd and hopeless, and which would not be adopted by the most careless and improvident proprietors, is precisely like the general, almost universal, condition of agricultural operations. How can it be otherwise? The proprietor usually has either wrong rules of action, or none—the superintendent, or immediate director, is seldom otherwise than profoundly ignorant of the science, if not also of the art of agriculture—the implements are defective—and the laborers unskilful in their use. Yet, under all such defects, which would speedily make any other business bankrupt, agriculture in Virginia, in general, is as safe and profitable an employment of capital and labor, as any other; which alone suffices to prove that it would be very far more profitable and productive of wealth, both to the undertakers and to the commonwealth, if it were possible to add to the productive power all that is offered by knowledge, and all the lights of the experience of the better instructed.

According to the wretchedly defective mode of education in this country, even the sons of the best farmers, and who may be designed to pursue their fathers' business, are debarred from all knowledge of it, until they commence, as proprietors, to bear the customary losses of ignorance and inexperience. If the father is wealthy, the son is kept at school and college until arrived at manhood; and then if he becomes a farmer, he is almost as ignorant of the business as if he had never seen it in operation. Every one, rich or poor, alike commences farming as head of the establishment, utterly ignorant; and the far greater number remain through life, without being much more enlightened. The first losses, of course, fall on the particular individuals who are so illy qualified as farmers; but their loss is also the loss of the whole community; and indeed no other individual, however little connected with agriculture, can miss paying some share of so enormous and permanent a drain from the wealth of the nation.

Having attempted to depict and expose the existing evil, we will now proceed to consider the different means for remedy; the means by which, it is believed, the knowledge of agriculture would be widely diffused and greatly augmented, and its improvement and its profits be proportionately advanced. The institutions which are deemed the best to advance the great object in view would be the following; which might be adopted altogether, or but in part, according to the intention of the legislature to operate either on a large or a small scale.

1. A state Board of Agriculture.
2. County or district Agricultural Societies, to be represented either in the Board of Agriculture, or in a general or State Agricultural Society.
3. A farm for experiments, which will also be a school for practical instruction in agriculture, in each of the four grand divisions of Virginia.
4. Surveys and reports of the actual agricultural condition of the different districts of Virginia.
5. A professorship of scientific agriculture, and its kindred sciences.
6. The establishment of cheap periodical or other publications on agriculture, for general circulation; and cheap school books to supply every pupil reading English; and of which the subjects should relate to agriculture, the mechanic arts, or something useful and instructive in domestic economy, or the ordinary business of the future lives of the pupils.
7. The facilitating and encouragement of agricultural apprenticeships, or practical and manual instruction, on the farms and under the direction of some of the most intelligent and successful cultivators.

Let not the reader, even if a legislator, be startled at the length of this list. It may be limited as closely as may be desired; and one measure alone, and that the cheapest of all, may be carried into useful operation, even if all the others be postponed or rejected. But as we are not legislating, but merely suggesting subjects for legislation, each and all of the measures most likely to aid the improvement of agriculture will be here considered, at more or less length, in proportion to their supposed relative value and efficiency.

Board of Agriculture.

The institution and proper working of a board of agriculture would be the most simple, cheap, and at the same time the most certainly efficacious, of all the means proposed in aid of agricultural improvement. If operating alone, it might produce results much less important than other means; but it could not fail to do some good, and could not possibly do any harm, beyond the small annual cost of the institution.

The best manner of constituting the board, or of selecting the members, would depend upon whether this measure stood alone, or in connexion with agricultural societies. In the former case, the appointment should be by the executive branch of the government; in the latter case, it might be well to give the societies, or their delegates, the power of appointing some of the members of the board. In either case the number of members need not exceed two or at most three, from each of the four grand divisions of the state, or from eight to twelve members in all; and also,

howsoever chosen, it may be presumed that the members would be among the most intelligent and best farmers of the state.

A body thus constituted, could, by proper inquiry and examination, draw forth from every region, reports of the condition, the existing advantages and good practices, and improvements in agriculture, the knowledge of which is confined to the narrow limits of their respective small neighborhoods, and which therefore, in each particular case, is hidden from, unknown, and useless to the country in general. Though information so gathered might be but general, loose, and but little satisfactory, compared to what better means might elicit, still, what was gained would serve to sharpen curiosity, and direct inquiry to the sources of more full explanation and instruction.

But a more important operation of such a board would be to examine well and learn the wants of agriculture, which legislative aid could provide for, and remedy; and to report the evils found, and recommend the specific means for relief. The opinions and recommendations of such a body, could not fail to be heard with respect; and there would be ground for hope, that thus, cautiously and gradually, the best of other means would be devised for doing the greatest possible service to agriculture, and consequently to the country at large. The investigations, the experience, the judgment, of the members of a board of agriculture would serve to settle, in the most satisfactory manner, the comparative claims and merits of all other means for aid and improvement, such as the remaining subjects which it is proposed here to examine in succession.

The board should have permission to recommend any thing, but power to enact or establish nothing, unless by special order of the government. Thus it might induce much future good to be done, and it could, directly, do no harm, nor commit the legislature to any undertaking whatever.

The main recommendation (as we fear it may be deemed) of a board of agriculture must not be forgotten—the *cheapness* of the establishment. The annual sessions need not exceed two weeks in length; and the whole cost need not exceed fifteen hundred or at most two thousand dollars.

COMMERCIAL CONVENTION.—CONTINUED.

Report on Direct Trade and Internal Police.

The committee, appointed to report on the subject of a direct trade with foreign nations; and to suggest what legislation may be necessary on the subject, beg leave to report:—

That they find it difficult to illustrate the magnitude of the evils resulting from a system of indirect trade, and will remark, that a full review of the past history of Virginia would better elucidate the subject, than any argument which could be urged by them; but the time of the committee will not allow them to treat this topic as it deserves.

That Virginia has once enjoyed a direct trade, and all the benefits attendant upon it, all will admit. Scarcely a town in the tide-water region but shared the direct trade to a considerable extent, while at present our most important marts are tributaries to the north to nearly their whole amount of business. When they enjoyed the direct trade, our cities, towns, and country were alike prosperous, and emigration did not desolate our land. With the loss of that trade, our small towns fell to ruin, our cities were made desolate, and our population have been fleeing from our borders; while those towns which have obtained our business in other states have grown rich upon our resources, and have increased in wealth, and numbers proportionate to our decline. During the state of colonial dependence, the several colonies were prosperous in proportion to the amount of their surplus production, and their means of consumption, but the reverse is now the case, those who raise the greater portion of the exports and consume most of the imports deriving no profit, but sustaining a heavy loss from the operation.

In spite of the loss and injury sustained by emigration and our perverted system of trade, agriculture has advanced very considerably, and even the tide-water section yields a greater surplus than in the season of the greatest commercial prosperity. But even in this respect, we are not as prosperous as those states that enjoy a direct trade, although their natural advantages are far inferior to ours. This is painfully manifest from the fact that in 1836 the whole assessment value of the lands, houses, &c. &c. of Virginia was but $207,000,000, a sum less than the assessment value of the real estate in the single city of New York for the same year. Your committee are unable to state the value of the personal estate of Virginia for that year, but perceive that the real and personal estate of the city of New York was over $309,000,000! The humiliating fact also occurs to your committee, that the value of all our lands and improvements, including valuable city lots, &c. does not exceed on an average, five dollars and ten cents per acre, a price which it is confidently believed might be realised to the United States, were Virginia a territory, and a wilderness, and her lands offered at auction on a liberal credit! Now, if it be considered, that the citizens of other states enjoy almost the entire benefit derived from all the profitable branches of our business, we see strong inducements for our most enterprising citizens to leave us and locate in other states with a view of reaping the profits of that business which ought to be enjoyed at home, and thus to lend their unwilling aid to our farther impoverishment. Experience too clearly proves that there is nothing in our agricultural prospects to stay the progress of emigration in the present state of things; for in all the states, north and west of Virginia, and in all the countries of Europe, the labor bestowed on lands in the way of improvements, adds to their value, and to the general wealth of a state, while with us, if such a hope were entertained, the past would afford a melancholy refutation of its justice. If we look to Virginia and the southern states, and then to the states of Europe, the contrast will be striking. All foreign states enjoy a direct trade, and furnish their retail dealers within their own borders, thereby giving to their own cities and people all the profits arising from negotiating exchanges and furnishing supplies—which is a main source of commercial power placed beyond our reach, so long as we allow those foreign to the jurisdiction of Virginia to pocket the profits of our trade. It is believed that, if Virginia were to convey to the northern ports the value of $5,000,000, as a gratuity, to be substracted from her

means and added to the capital of the north, and yet prosecute a direct trade in foreign and domestic supplies through the medium of our own ports to the extent of the remainder of her resources, she could be far more prosperous than at present. It is evident, that the loss of Virginia, in consequence of the indirect trade, exceeds the profit of the northern merchants who monopolize our business, inasmuch as not only the same profit, which would accrue to the southern importer, must be paid abroad, but the incidental expenses of freight, insurance, travel, &c. must also be added to our detriment.

It appears to your committee, from the best evidences in their possession, that the profits paid to northern cities on merchandise by Virginia, North Carolina, South Carolina, and Georgia, from 1816 to 1836, a period of twenty years, were greater in amount than the public debt of the United States which was liquidated in that time, amounting to $170,000,000, with interest thereon; and had the south retained the direct trade, they believe that the increased value of property in her cities and towns for that period would have nearly reached a similar amount; and, as it is obvious that rich and flourishing cities enhance the value of the property of the entire states to which they belong, every foot of southern soil would have been enriched by that process. It may here be stated, that Virginia and North Carolina do not even enjoy a direct trade with New England, as the greater part of the manufactures and products of that section, which are consumed in the South, are obtained from New York, Philadelphia, or Baltimore, and come to us well laden with the charges of the indirect route. Looking at our present commercial policy in all its results, your committee are constrained to adopt the opinion, that such another instance of self-immolation is not to be found in the annals of the world.

They beg leave further to illustrate the benefit of a direct trade, by stating the fact, that in all civilized states, which enjoy their own business to a respectable amount, compared with their resources, more than a moiety of the wealth will be found to be located in their marts of commerce and business. In all the states north of us this principle will apply with full force. It is true that the trade of many of them is of late becoming indirect, and their present ratio of increase of capital is not as uniform as formerly; yet at this time in Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware and Maryland, either under a system of fair taxation may draw more revenue from its marts of commerce and business than from all other portions of its territory. But this is not the case with Virginia, as the assessment value in her four principal seaports is but about $19,000,000, which is but about one-eleventh part of the value of real property in the state, which is as follows:

	Value of Houses.	*Val. of Lands.*	*Aggregate.*
Richmond,	2,639,344	8,001,540 82	10,640,884 82
Norfolk,	2,188,625	2,704,430	4,893,055
Petersburg,	1,921,494	866,011	2,787,505
Fredericksburg,	233,221	832,897	1,066,118
	$6,982,674	12,404,878	19,387,563 82

We find again that in many of the states of Europe from one third to one half of the population draw their subsistence from the business marts; and in the Atlantic states about one-fifth of the population are thus located; but Virginia is very deficient in her quota, she having but about 49,000 souls in all her towns which have over 5,000 each, (which includes the enterprising but neglected towns of Portsmouth and Wheeling,) our whole population being estimated at 1,300,000 souls; and therefore, whilst the Atlantic states, as a whole, have a business population in the proportion of one to four, Virginia has but about one to twenty-five, and while our agricultural business is capable of sustaining by this ratio, a population in our marts of business of over three hundred thousand souls! It is therefore very manifest that we sustain a much larger business population in other states than in our own, and that the value of real estate in the cities of other states, is great in proportion to the amount in consequence of business which they derive from us. The value of country property in other states is also augmented by the increased wealth and population of their cities, which we sustain to the neglect and ruin of our own.

Your committee find that the British colonies in North America are in an enviable condition compared with Virginia. The Canadas, with an aggregate population less than Virginia, sustain a population in their business marts as great as Virginia, North Carolina and Georgia together, and they have few or no mechanics or artizans, and they look to the mother country for even horse shoes, and horse shoe nails, and the most common articles usually made at home.

In the island of Cuba (which is as convenient to New York, as the state of Alabama,) we find that the whole population is less than in Virginia —and yet we find that its numbers about triple our number of business population, and that the wealth and revenues of her ports is greater than from all her interior, and it is evident that her retail dealers procure their supplies in her own marts.

The same is the case in reference to Jamaica, and it appears evident that if all the retail dealers in those islands were to obtain their supplies in New York, that their present flourishing and prosperous ports would soon be reduced to the condition of our Cobham, York Town, Tappahannock, or City Point, and the destruction of those ports would be ruinous alike to the prosperity and security of the inhabitants of those islands.

Your committee find that there is no state in Europe which has not made a greater proportionate increase in population and wealth compared with their former condition, than Virginia, and the same comparison will apply with full force in reference to all our northern states.

Your committee are of the opinion that the concentration of the trade of Virginia in her own ports for a single year, with the prospect of its continuance to an amount equal to furnishing the supply for the consumption of the people of the state, would produce an increased value of property in that short period to the amount of not less than fifty millions of dollars. This it is admitted looks extravagant, but it must be borne in mind that property is valuable in proportion to the useful or beneficial purposes to which it may be applied. If the country dealers and planters would purchase the amount in our ports which they now purchase in those of other states, it would be found that our present state of agricultural strength would require and support a seaport population of

over 200,000 souls. This would triple the surface of our towns, and more than quadruple the actual value of the lands therein. Buildings which are now being erected in other states upon the profits of our business would start with magic enterprise with us; and the money paid for their materials and construction would remain the property of our citizens. Lands in the vicinity of our towns would enhance in value, for lumber and fuel, while agriculture would find a new stimulus in furnishing productions to those who now subsist wholly at our expense, and to the profit of others.

If time would permit, your committee would attempt to demonstrate that the consumption of the state of Virginia, of commmodities, the produce and manufacture of which is foreign to her jurisdiction, is as great as that of the whole United States was, so lately as the year 1790; and will leave to this convention and to history to answer, whether the trade of these United States was considered of such importance as to induce national efforts (which have been successful) to enable the United States as a whole to enjoy equal and reciprocal commerce; and to inquire, is not an amount of trade which was worthy of the concerted action of the United States in 1790, at least worthy of a united and patriotic effort of the people of Virginia in 1838?

Your committee assume that the mercantile profits of export commerce from the state of Virginia is about one-eighth of the profit of the import, including with the import however the furnishing all the varied supplies for the interior. Were we therefore to export our whole productions and furnish at first hands none of our supplies, we should enjoy but one-ninth part of the profits of our business. If this position be correct, it behooves us to place ourselves in the possession of the business of furnishing the tide-water region of our state before we mature large schemes of internal improvement, to confer more trade at our cost on our rivals whom we now see possessed of that which nature designed for us, and of which we can only re-possess ourselves through that reserved sovereignty, which it is our right to exercise by a legal regulation of our internal police.

Your committee find that the evils of an indirect trade are not exclusively felt by the states of Virginia and North Carolina, but by many other states; and when they look at its result, and observe that it is verging towards a commercial consolidation of the whole pecuniary energies of this great confederacy in a single city, they cannot contemplate our condition, but with dismay; more especially when we consider that we pay our rivals one hundred dollars for what costs them about seventy dollars on the average of our transactions; and this is the boon which we obtain in going from home, not to buy supplies, but to buy credit in obtaining them.

On reference to the history of trade in the old world, and of its concentration, your committee are constrained to adopt the opinion, that it is not, nor has it ever been, absolutely free. It has, indeed, ever been subject to legal direction in all civilized societies, and in those not civilized there is but little or no trade to receive the fostering aid and protection of legislation. All the states of the old world have at least one point of commercial monopoly; and it is admitted by political economists, that the trade of an empire will find a point of supremacy within itself for all its large business; and that the smaller trade will, and should be subordinate to such concentration, which is the effect of legislative provision.

This result must be expected under any consolidated government, and it is evident that the trade is subordinate to law, or the seats of business in each nation would not, in all cases, be within herself.

It is urged by many, however, that under our federal system, we must submit to what they call the "inevitable law of trade," which they say is that of consolidation of all commerce at a single point; and such has been the perpetual tendency of the business of the United States for the last forty years. It is also admitted, that this may have been the result of governmental action; but if it be so, it has not been by the design of those who have administered our affairs, but the fault of the people of the states, who have permitted this concentration. It must be observed, that our government is not one of consolidation, inasmuch as the federal government regulates all foreign business, whilst that of each state may regulate its internal concerns as its wisdom may direct. It does not, therefore, appear to your committee, that the trade of the United States will necessarily remain consolidated any longer than those acquiesce in such a state of things, who are impoverished by its consequences. That there is abundant power over this subject, reserved to each state, is evident on reference to the fundamental principles of our government, and to the causes which led to the formation of the constitution of the United States.

That your committee may be sustained in the premises, they present herewith the opinion of that eminent jurist, James Kent, formerly chancellor of the state of New York, which they trust will be received as good authority, sanctioned, as it is, in its doctrines, by the decisions by Chief Justice Marshall, in the case of Brown vs. The State of Maryland, and Gibbons vs. Ogden.

"CHANCELLOR KENT'S OPINION.

Questions.

1. Is the law of the legislature of Massachusetts, passed the 19th of April, 1838, and entitled "an act to regulate the sale of spirituous liquors, constitutional, and consistent with the revenue laws of the United States?

2. In what manner can a violation of the license laws of Massachusetts be carried into the supreme court of the United States?

These two questions have been submitted to me, as counsel, for my opinion thereon, by a gentleman of the city of Boston, who considers himself interested in the inquiry.

Opinion.

1. The act alluded to, declares, that "no licensed innholder, retailer, common victualler or other person, except licensed apothecaries, physicians and others, who may sell spirituous liquors to be used in the arts, or for medical purposes only, shall sell any brandy, rum, or other spirituous liquors, or any mixed liquor, part of which is spirituous, in a less quantity than fifteen gallons, and that to be delivered and carried away all at one time, under a penalty, from $10 to $20 for each offence."

The former statute in relation to this subject, of

the 20th of April, 1837, declared that no licensed innholder or other person should sell any intoxicating liquor on Sunday, under the penalty of $20; and that if any person should have been three times convicted of a breach of the act, *or of the 47th chapter of the Revised Statutes*, he should be liable to severe specified penalties and punishment. It is to be observed, that the 47th chapter referred to, has twenty-nine sections, and several distinct offences and penalties are declared in it, all relative to the regulation of licensed and selling of spirituous liquors.

I have attentively considered the first question, and I have satisfied myself that the statute of last April, therein mentioned, is not repugnant to the constitution or laws of the United States. I am of opinion, that the statute in question relates to the internal police and government of the commonwealth of Massachusetts, and that it was competent for the legislature to pass it. The government and laws of the United States have no concern with the internal regulations of the states. These regulations belong exclusively to the power and authority of the state governments, and they may pass what sumptuary laws they please in restraint of the interior commerce of the state, and of the manners and habits of the residents therein. All such regulations, however stern they may be, rest entirely on the wisdom and sense of expediency and policy of the local legislature, provided they be consistent with the constitution of the state.

In the case of *Brown vs. The State of Maryland*, (12 Wheaton, 419,) the validity of a state law, in restraint of the importation laws and foreign commerce of the United States, was fully discussed and considered. The doctrine of that case was, that a state legislature could not impose a tax on goods imported, *while the goods were in the hands of the importer, and in bulk*, and that a right to import the article under the laws of congress, and a payment of the duty, carried with it a right to sell it, free of any previous charge, or duty, or tax thereon laid by the state while in possession of the importer. But the case admitted that after the article had been sold, or passed into the hands of the retail dealer, and became incorporated with the general mass of property, it was subject in all respects to state regulation. It seemed to be conceded in the arguments in that case, that a power in the state to control the use of the article after it had passed out of the hands of the importer, would greatly and essentially affect the right of the importer to import, for who would purchase of the importer, if he could not afterwards use and dispose of the article? But this was a consequence that could not be avoided, without going too far in the denial of the right of the states to regulate, in their discretion, the internal commerce of the state. It was admitted by the court in the case of *Gibbons vs. Ogden*, (9 Wheaton 203,) that state inspection laws, health laws, and laws for regulating the internal commerce of the state, &c., were not within the power granted to congress. We may add that the power regulating auction sales, and hawkers and pedlers, and markets, are all within the discretionary power of the state legislature, as much as the power concerning the sale of lottery tickets, or the preservation of the health and morals of the citizens, by interfering with the sale of obnoxious articles. These and a thousand other cases that might be put, all fall within the general superintending discretion of the state governments, as part of their own constitutional control over their own internal trade and dealings, and customs.

I consider this to be the doctrine of the cases of *Gibbons vs. Ogden* and of *Brown vs. The State of Maryland*, both of which were decided under the liberal and sound judgment of Chief Justice Marshall; and I am persuaded that the act of Massachusetts of April last would have been regarded by the supreme court, when they decided the case of Brown, as entirely free from constitutional objection, for that statute does not touch the importer, except very indirectly. It only goes to restrain the retail of spirituous liquors under the quantity of fifteen gallons at a time, and it evidently assumes that the article has passed from the importer into the internal commerce of the country. The importer may sell in that quantity and upwards at home, or for exportation to other states.

And if the case was doubtful under the decision in the case of *Brown*, yet there is a more lax construction on state authority in the late case of *New York vs. Miln*. (11 Peters, 1839.) There the court repeat all the exceptions in favor of state control over imported articles, mentioned in the former cases, and show a decided leaning in their favor. They go so far as to say that a state law which concerns the welfare of the people within a state, and relates to their duties as men and citizens, and to persons and things within its jurisdiction, is a regulation concerning the internal police of a state. No doubt the sumptuary law in question, prohibiting the sale of spirituous liquors, falls within the rightful cognizance of the state governments according to the doctrines of the supreme court of the United States, and I am very decidedly of the opinion that it would be fruitless to appeal to the supreme court of the United States against a decision of the supreme judicial court of Massachusetts in favor of the validity of the state law.

2. As I am of opinion that the act of April 1838 is not against the constitution or laws of the United States, the second question becomes unnecessary. Yet as the gentlemen who have done me the honor to consult me, may still be disposed to try the experiment, I should in that case advise, that whenever a suit is brought for a penalty for selling contrary to the act, that the defendant demur to the bill or declaration, or set up by way of defence that the act is repugnant to the constitution of the United States, and if overruled, as he would be, that he appeal to the supreme judicial court of the state, and if the judgment against him be affirmed, as it would be, that he then, under the direction of the counsel who has conducted this defence, appeal by writ of error to the supreme court of the United States, and a decision there will put an end to all litigation on the subject.

JAMES KENT."

New York, May 12, 1838.

If this opinion is tenable, we may lay a tax on foreign goods coming coastwise or in any way indirect to our state, except they be in original packages and on the importer's account; and we may do the same in regard to our American manufactures, which now pay tribute to indirect routes, all of which rights we may and should exercise in virtue of our sovereignty over our territory and population.

Your committee see no objection to the im-

mediate legal adoption of this alternative; but they deem that it will be inexpedient to recommend the adoption of that which the public mind is not prepared to sanction, until this subject shall have received their further consideration. They beg leave, however, to recommend an amendment to the law in relation to merchants' licenses, which is no other than a legal exercise of internal police which exists in every state of the Union; some having adopted its use for the purpose of protection of various persons or branches of trade, and others for revenue. In the states of Virginia and North Carolina it has been adopted both as a system of revenue and a measure of internal police, and may with advantage be altered and amended to the great improvement of both objects. In the year 1837 we had fifty-seven wholesale merchants, as follows:—Norfolk 19, Richmond 17, Petersburg 16, and Wheeling 5, each for the consideration of $60 per annum. In the same year we had eighteen auctioneers, to wit: Richmond 6, Norfolk 4, Fredericksburg 3, Lynchburg 2, Wheeling 2, and Portsmouth 1, at the sum of $90 per annum. In the same year there was granted to the 115 counties and 8 cities, boroughs, &c. 3836 retail licenses at $20 per annum, all united producing a revenue of near $73,000.

Your committee estimate that the retail dealers purchased goods, wares and merchandise in the said year, to the amount of $38,736,000 and estimate the rates of their purchases as follows:

No. of merchants.	*Am't. of purchase.*		*Total am't.*
25 who buy say	100,000	is	2,500,000
50 do	75,000	do	3,750,000
75 do	50,000	do	3,750,000
100 do	40,000	do	4,000,000
125 do	30,000	do	3,750,000
150 do	25,000	do	3,750,000
175 do	20,000	do	3,500,000
200 do	15,000	do	3,000,000
250 do	10,000	do	2,500,000
300 do	8,000	do	2,400,000
350 do	6,000	do	2,100,000
400 do	4,000	do	1,600,000
500 do	2,000	do	1,000,000
1136 do	1,000	do	1,136,000
3836			$38,736,000

Of this amount it is believed that not more than $4,500,000 value of merchandise both foreign and domestic, were introduced into the state after the manner of a direct trade; and therefore a tribute was paid to the indirect trade on the amount of $34,236,000, which amount of supplies, if received direct, would not cost the merchants of our ports more than $25,000,000. But this is not all the indirect business, inasmuch as a very large amount of articles purchased of the consumers are purchased in other states by retail to the neglect and injury of the retail dealers who have paid the state for the privilege of furnishing the citizens with goods by retail.

Your committee beg leave to suggest the inquiry whether citizens who thus act the part of merchants to the injury of our own markets, and the prosperity of the state, should not in justice to the retail dealer, and to the revenue, pay some equivalent in the form of a license. It is manifest that the license law of this state was enacted with the design that the retail dealers should purchase their supplies from the wholesale dealers and auctioneers within the state; and were they to do so, the revenue would be greatly improved, as not less than five hundred wholesale dealers would be sustained at this time who now pay revenue to other states. If by discriminating licenses our trade were thus restored, the business of the state would command abundant supplies; and a direct export and import business and trade with the country would establish a sound condition of domestic exchanges, and save us from panic and alarm, when convulsions ensue consequent upon the over-trading of other states. And manufacturers, mechanics and artizans would find a prosperous home among us. It is notorious however, that our retailers purchase nearly their entire supplies in other states, and from dealers who contribute nothing to the support of our government, nor does the profit of the business add to our wealth or to the value of our town property; but, on the contrary, we are impoverished, inasmuch as the profits drawn from our labor and added to the capital of our rivals increase their strength in the ratio with which we become weakened and exhausted.

It is obvious that the little trade which we now enjoy is from our smaller retail dealers, and from them we derive benefit and they pay as large a sum for a license as the largest class of retail dealers: for example, those who purchase from one to two thousand dollars per annum, pay from one to two per cent. on the amount of their business for a license, and our larger dealers who purchase exclusively in other states pay only about one-fifteenth part of one per cent. for theirs.—Your committee, therefore, deem it due to justice and patriotism to reduce the license of the smaller class of retails, and especially those who purchase their entire supplies in the state, and recommend the enlargement of the same paid by dealers who purchase any portion of their supplies in other states, to a sum not less than two hundred dollars, and the adoption of a new classification of dealers is recommended, to be denominated the *Domestic* Dealers, being such as purchase exclusively within the state, and *Foreign* Dealers, those who introduce and sell goods from other states; and in this latter class we would embrace all commission merchants, factors and consignees who are the accesaries of the indirect introduction and sale of merchandise. Your committee are deeply impressed with the opinion, that this small amendment of our system of internal police, will immediately restore to our ports an export and import business, foreign and coastwise, to the amount of $30,000,000, annually; and if our merchants are found incompetent to supply the demand, those merchants who now enjoy the business of our retailers, will come from other states and compete for the rich boon which so simple a legislative remedy will wrest from them. Make our business worth competing for at home, and competition will soon, very soon, be equal to the demand. Your committee are incompetent to estimate all the advantages which would speedily result to our seaports and the towns of Winchester, Wheeling, Charlestown, &c. as they would command the trade of the retail dealers of each respective vicinity; and it will soon be manifest that under all the evils to which they might feel subjected from an enlarged license, that their larger operations would more than compensate, and

the several small dealers in their aggregate would be saved the labor and expense of about eight thousand journeys annually to northern cities to obtain that which can be obtained on better terms at home. It is an axiom to be relied on in all operations that a subdivision of labor facilitates perfection. Your committee will therefore add that our retail business may be done with far less capital, as the merchants who are near the markets from which they obtain supplies may purchase more frequently and not be subject to purchase at any time too large amounts, and less loss will be sustained to them by change of fashion or damage, or from the pecuniary pressure consequent upon the use of credit beyond the means of payment. This simple system (humble as it is) once put in operation, will enable the people to unite their best exertions with the great cause of internal improvement, which will soon render the remote portions of Virginia and North Carolina as familiar in intercourse as they are friendly in sentiments.

Your committee will further remark that a prosperous business will enable us to accumulate capital from our labor and enterprise; and they flatter themselves that future legislation will extend such fostering privileges as our best interests and *investments* may require.

Your committee, prompted by sentiments of filial patriotism and devotion to our *whole country*, will further add, that the restoration of our trade and prosperity, through the exercise of our clearly reserved rights, giving our citizens and all who become such, great benefits, without infringing on their equal privileges, or the rights of the citizens of other states, will be another patriotic example of the Old Dominion, which will be followed by her suffering sisters; and our equal prosperity and success will abate all sectional jealousy or envy, and preserve our UNION *for ever*.

Your committee beg leave to close their labors with the following resolution:

Resolved, That this convention appoint a committee consisting of twenty-one, whose duty it shall be to memorialize the legislatures of Virginia and North Carolina on the subject of their internal mercantile police and such other matters as are directly connected with the restoration of that trade which is enjoyed by citizens of other states.

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